ARROYO SECO

SCIENTIFIC AMERICAN SUPPLEMENT

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VOLUME LXXXIV] NUMBER 2190 * NEW YORK, DECEMBER 22, 1917 * [10 CENTS A COPY $5.00 A YEAR

A first aid team applying dressings to a subject in a public competition

SAFETY IN INDUSTRY—[See page 392]

The Human Potential in Industry*

National Efficiency, Now Expressed in New Terms

By Dr. Otto P. Geier, Cincinnati, O.

For the past three years history has been writing the terrible story of the human potential in modern war. As a result of a long period of peace, we Americans had looked upon war as a most remote possibility, attested to most strikingly by our state of utter unpreparedness. As we reflect, it appears now we were not measuring nations by their fighting strength, but rather by their social, industrial and commercial strength. Nations were tabulated for their rate of production and consumption. This differential had its social as well as its economic effect. It produced state and private wealth. It produced leisure, the arts, extended educational and health measures, and raised the standard of living. In brief, the world was in keen competition not only in business life, but in social life. Nations were striving to outdo each other in promoting financial success, health and happiness for their people. Individualism had reached its zenith and the philosophy of collectivism was just appearing above the horizon.

It was rather our subconscious minds that recognized the great sea power of England and the militaristic spirit of Germany. Our real attention was focused, not on the plans and intrigues of government, but rather on the national characteristics of their peoples. We thought of London as the financial center of the world, of the Englishman as the world traveler, a lover of outdoor life and sports, an educated gentleman and judge of the fine arts.

When we traveled in Germany we admired her order and cleanliness, her *Gemüthlichkeit*. The world paid homage to her philosophers, revered her musicians, studied and copied her educational systems and longed for her thoroughness and scientific capacity.

POTENTIAL OF WAR.

But the bloody struggle of the past two years has changed our viewpoint of these nations. War, with all its horrors, its terrors, has changed these peoples. The human potential of nations is no longer directed at the creation of comforts, contentment and health, but the backs are bending low under the struggle of destruction of property and life. National efficiency is now expressed in new terms.

Shortly after the program for the Spring Meeting of this Society began to take form, our country entered the war. There were those who doubted the advisability of holding the meeting. Our fearful unpreparedness produced a public state of mind akin to hysteria. We had scarcely had our sober, serious second thought. Democracy is being subjected to the acid test. There are few so daring as to prophesy what failures and what successes we shall find. Of one thing we see signs. Our nation is finding itself. We are trying to forget and forgive ourselves for our "spread eagle" and forget our jingoism. Even in the early stages of preparedness we are intensively appreciating, as never before, the stuff that other nations are made of. Their capacity to produce, their silent ability to suffer, sets us to wonder.

AMERICA REBORN.

Perhaps, for the first time since the Civil War, we are thinking together. Our national consciousness has been reborn. The pettiness in us is disappearing and true Americanism is coming to the foreground. Our faces are turned to the common enemy. We have turned our backs on the paltry bickerings of the past. We are witnessing the first truce in the century-old strife between labor and capital.

This is a day that calls for statesmen as well as soldiers, for calmness as well as courage, for patience and patriotism, for virtue and vigor, for faith and faithfulness, for health as well as willingness to die. This day calls for social reconstruction as well as enemy destruction. Huge is the task in which *all* should find a place to do with all their hearts.

POTENTIAL OF INDUSTRY THE POTENTIAL OF THE NATIONS.

And what tasks has our entering the war brought to industry? Huge production? Yes! But is that all? Have not old truths as to the value of the conservation of labor taken new form, new emphasis? Has not The Human Potential in Industry in the nations abroad finally been the measure of their potential on the battlefield? Has the interdependence of man ever been more fully demonstrated? Has the mutual dependence of labor and capital ever been so strikingly proved? Have we ever witnessed such limitless industrial energy and output? Has it occurred to all of us Americans, that Europe's industrial experience of the past three years holds not only a lesson but a warning? Militant and efficiently industrial England of war times will be succeeded by industrially militant England of peace times. Labor and capital in England, Germany and in France, having learned the mutual advantage of co-operation in war, are not likely to give up this advantage and return to the destructive internal warfare of former days.

OUR NEW COMPETITION.

The question that presents itself is this: Can we keep pace with them in war, and will we keep pace industrially after the war? Can we stand this new type of competition unless we, likewise, enter upon the program of the new social order? Will not the programs of our National Association of Employers, chiefly defensive in the past, necessarily become socially constructive? Will not labor now have to seek leadership capable of best adjusting itself to these forward-looking steps.

FORWARD-LOOKING INDUSTRY.

War has lifted the discussion of "the human potential in industry" out of the realms of philosophy and has used it as the foundation stone of a national economic policy. The Council of National Defense has appointed a committee on the conservation of the health and welfare of the worker, and in the interest of the health and productiveness of labor proposes to establish definite standards of plant operation. The human potential of the nation is needed at its maximum, for the country cannot afford the usual labor losses due to accident, disease or fatigue, and industrial poisoning.

A right-minded, forward-looking man does not wait for compulsory legislation to develop his business organization to the highest degree of efficiency. This type of man, for years, has developed not only the administrative and technical divisions of his plant, but, when most successful, has given a great deal of thought to the human equation; the giving of happiness and meting out of justice to his employees. It has been a great satisfaction to him to find an economic method of lessening the human waste due to preventable accidents and occupational diseases. He noted that a healthy, contented employee was a more productive employee, who, in turn, was a higher type of citizen, demanding a better standard of living for himself and family, better protection for his children against disease, delinquency, and crime, and higher forms of community recreation. He recognized that right in his plant he could make his best contribution to the health and well-being of the worker, and that he had found, perhaps, the most tangible basis for co-operation between himself and his employees. To him it was apparent that by intensively studying the health of his workers he was establishing some splendid new points of contact between himself and his men.

MASTER AND MAN, THEN AND NOW.

Industry must find a substitute for the valuable relationship of master and man which passed with the coming of greater industrial concentration. Then the master was teacher as well as craftsman and to a large degree a substitute for our modern continuation school, manual training and co-operative university engineering course. Master and man worked elbow to elbow. The master largely molded the thought and living of the man. Then they had real personality for each other. Now, in too many instances, the pay envelope expresses the only bond between the two. The man was graduated from his apprenticeship, frequently to set up a business of his own; now, industrial concentration practically hinders the establishment of the new small unit. Then, labor took part in the making of the mechanism and conceived the full purpose of the machine which he assisted the master in building; now, his work is more repetitive and limited to single parts of a machine, whose mechanism he may not understand.

TENEMENT STRIKES, LOCKOUTS.

It was but natural that in this evolutionary process of industry, capital and labor should become more estranged. They not only worked farther apart, but lived farther apart, for with industrial concentration, community life changed, and the tenement district developed. The difference in their scale of living was more evident. Industrial discontent was more readily bred. Labor and capital organized themselves to meet strife, and strikes and lockouts were the natural outgrowth.

Neither master nor man can be held accountable for these unfortunate conditions, which were but the natural consequence of industrial evolution and the consequent crowding of population in cities. So engrossed were both labor and capital in adjusting themselves to the new conditions that the estrangement of these former partners in work came on quite unnoticed.

DISTRUST OF EARLY WELFARE WORK.

Some years ago industry began to recognize its social obligation. It saw the economic advantage of substituting fine, light, well-ventilated buildings for the dark, unsanitary workshops of the good old days. It was at about the same period that many abortive attempts at so-called welfare work were started, which in most instances failed to make any real contribution to the better understanding of labor and capital. This sort of welfare work was established on purely paternalistic lines, was imposed upon the group of workers without their desire or consent, and all too frequently furnished that for which they had no real need. This type of welfare contributed to the social and superficial requirements of the man, and overlooked the fundamentals. It did not take into account the basic principle that the workman is very human, and that to get the best results out of any socializing effort you must first engage his co-operation. You must put him to work, so that he too may use his creative instincts, and enjoy with the employer the fruits of intelligent co-operative work. Welfare work of the former kind deserved failure and did fail. It was "built upon the sands" and was all too frequently washed away by the least wave of discontent among the workers. After the first strike, the returning man found the doors of the dining rooms, libraries, and club rooms closed upon him. The whole structure was weak and crumbled at the mere sign of a storm. Is it any wonder then that welfare work came into such disrepute with the workers and was so continuously and effectively used by the labor agitator?

BUILDERS OF MEN.

It would, indeed, be a foolhardy individual who should attempt to interest the members of these organizations in that kind of welfare work. I am equally sure that most of the plants represented by this conference are already engaged in some effort to solve the great problem of human potential in industry. We are all groping our way toward finding the right method. If we can evolve a sound economic scheme for the establishment of a human-service department in industry, which day by day will pay dividends, which will reduce lost time for illness and accidents, reduce labor turnover, and quicken loyalty, we will not build up a "blockhouse" which will fall to pieces at the first sign of industrial strife. It will each day have served its purpose, secured a result worth while for itself, and will automatically, along with all other departments, be again set in motion the moment that the wheels of industry begin to turn.

I have faith in big industry. I believe that when builders of big enterprises sense their social opportunities they will also prove themselves to be builders of men. In time their widened perspective will include an active interest in national and local health problems, they will, for the sake of the men, use their good offices for better housing and transportation facilities. They will apply themselves to the great human problem of taking much of the drudgery out of work. With this new purpose in life will come a recompense which cannot be valued in mere dollars.

They will be instituting the first intelligent effort toward the alleviation of poverty and the establishment of social justice. Philanthropy and legislative effort to correct conditions have failed lamentably.

BUILD UPON HEALTH.

The activities of the human-service department should be founded on intensive health work. Health is our

* From the *Journal of the Am. Soc. of Mechanical Engineers.*

most vital possession. The mere act of conserving the health is ennobling. Healthy bodies promote right thinking, right living, good habits, and it is upon such factors that intelligence, stability and loyalty are engendered. Unless we have these things, our employment departments, struggling with the labor turnover, our mutual benefit societies and loan associations, our restaurants, our co-operative buying, our sanitary measures, will meet with but half of the deserved success.

ALL-DAY DISPENSARY.

The point of approach to the human potential had best, therefore, be through the industrial dispensary. Under a high-grade physician it will be the great melting pot of the human experiences of men. Here the virtues and the weaknesses of the men will be most apparent. The physician will also be confessor, adviser, priest. Through him the employee may learn that it pays to be healthy, steady, and of good habits. He does not hesitate to preach the "Sober First" campaign.

An industrial dispensary, with a dental clinic as its adjunct, will advertise itself. It will come in daily contact with five per cent. of the force, the equivalent of the whole force each month. To respond to all the possible services that grow out of these frequent contacts, it will require one full-time physician to every 750 employees.

The men will first use this department for their slight cuts and accidents; next they will begin to call the doctor's attention to some surgical defect with which they have been suffering.

DOUBLING WAGES.

I recall the case of an Italian watchmaker with five children, whose complexion was pale and pasty. He seemed anxious to please his foreman, but his work, like his skin, remained rather pale. He had a bad record for absence and lateness. His average earnings amounted to $13.00 per week. Investigation showed that he had been suffering with hemorrhoids for twenty years and had been repeatedly advised against an operation. He had enough confidence in the plant physician to undergo the operation. As a result, his physical efficiency was raised, so that now his premium earnings are nearly as great as his weekly wages formerly were. In other words, the operation had practically doubled his wages. An inefficient man, an active candidate for the human scrap heap, one whose family had been on the poverty line for years, has been converted into a happy, productive citizen.

In an industrial all-day dispensary men will frequently learn that while they have been treated for rheumatism on the outside, they are actually suffering from broken arches. Again and again men will be found who are continually taking headache dope for headaches due either to gastric conditions or eye strain. Untold numbers of men will be found whose working capacity has been below normal; whom employers have always felt more or less sorry for and therefore did not discharge because they seemed anxious to make good, but they never quite "reached." Quite a lot of these will be found suffering with chronic intestinal toxæmia, while fully as many will be discovered whose lowered vitality has been induced by years of bad mouth hygiene, abscessed roots and pyorrhea. I am thinking just now of such a man who had been treated for rheumatism for years and who never was able to get out of the subnormal class of workers. A careful checking up showed pyorrhea of the teeth to be responsible. With six months' supervision and care, that man increased his earning capacity by nearly 100 per cent.

While speaking of mouth conditions, let me recall the case of a man who for three weeks suffered excruciating neuralgia of the face and head. He was the type of man that puts off going to a physician until the last moment. Examination showed that he had a very dirty mouth, a number of snags and some pyorrhea. X-ray showed an unerupted cuspid tooth lying horizontally, the pressure therefrom causing the pain. Twenty-four hours after the removal of this tooth, and the old snags, all pain disappeared. If the plant dentist had been an average dentist no X-ray would have been called for and the man would, for weeks, have lost sleep and time from work, and have considerably reduced his vitality and working capacity.

In passing, we might mention one other case where the man was losing a day or two each week as a result of nausea, sleepy, draggy feeling, practically no ambition for work, and gradual loss of weight. Physical examination showed nothing unusual, except that the teeth were bad. Cleaning up the mouth and pulling out the old snags was followed by immediate improvement. The stomach trouble disappeared. In six weeks he gained seven pounds and had a new bite for work.

DIAGNOSIS NECESSARY.

The plant dispensary, with the economic pressure back of it to get results, will go farther to establish a diagnosis than the family physician. It sees the financial advantage to the patient and to the company to spend a few dollars for consultation or for X-ray. If the employee cannot pay for the consultation, the plant physician can always place his hands upon some consultant on the outside who will do the work for nothing. There is a drive behind the plant physician to get a quick result.

Too much cannot be said for physical examinations of employees. No one knows how many cases of incipient tuberculosis are present in his shop force. There are any number of men whose appetites are variable, who tire easily, but who have no cough or symptoms that would make them consult a physician; are perhaps merely irritable, and have a draggy feeling and no "pep." They attribute their weariness to the job. In so many cases of an early diagnosis of incipient tuberculosis, an enforced rest of a month or two will put these men on their feet again.

INDUSTRIAL CROSSED EYES.

The development of the human potential with all of its mutual and economic advantages will not be introduced in industry where the employer does not possess some social vision. I am thinking just now of one narrow-visioned employer who was recently interviewed by someone who was anxious to gain a consensus of opinion as to the value of employees' service departments. The total human equation in this particular industry, employing some 1,100 men, was represented by a mutual aid to which the company contributed annually the large sum of $100 (less than nine cents per man). It was necessary for that association at their annual picnics, given for the purpose of raising money, to invite employees of a number of other smaller concerns. In other words, for the sake of a few dollars raised by inviting outsiders, this company blindly encouraged the undermining of any good feelings of fellowship that might have been encouraged among its employees by this one annual getting-together. The same employer boasted that the efficiency plan of wages greatly reduced the cost of production, returning ten dollars for each dollar put into that system.

A LOW-BROW HIGH TURNOVER.

In discussing his men he spoke only of their lack of loyalty and the lack of loyalty on the part of the foremen. With an injured air he told that petitions for the unionizing of the employees had been in circulation in his shop for two weeks, with the full knowledge of the foremen, before he discovered that fact. The result is, he says, that the shop is fully organized and the union has his company under its thumb. It seems that it had been the custom of this company to entertain the foremen once a month with a dinner and smoker, and that one of these entertainments was held the night before the discovery of the petitions. With stupid satisfaction he said that thereafter foremen's meetings ceased. It is not surprising to note in passing that the labor turnover in this plant is 305 per month. This man who gives the whole sum of $100 toward the sole co-operative effort on the part of the men to care for themselves in times of illness loses $100,000 per year in excessive labor turnover.

If I were called upon to make a diagnosis of that employer, I would venture to say that he had an aggravated case of mental strabismus or was mentally cross-eyed. He does not realize that the sound-minded industrial procession is passing him. He does not know that the movement for the conservation of the industrial worker marks the greatest change in the attitude of society of the twentieth century, that next to the municipality the industrial corporation is the largest social unit, that as such it partakes of many of the characteristics and functions of a governmental subdivision. He does not realize that his industry is an example of one selfishly administered, and as such is a menace to the peace, prosperity and happiness not only of the members of his industrial unit, but a menace to the rest of the community members. A coldly calculating, selfish enterprise, no matter how big, engenders selfishness, distrust, envy and hate in individuals in and about it. As a by-product it manufactures class feeling, which other social agencies vainly try to counteract. Conversely, a socially organized, profitable, and farsighted business enterprise, by its very existence, continuously creating more work for more people, is not only a great financial asset to the community, but is of definite social value as well. The first grows at the expense of society which gave it life. The second is one of the taproots of society. The first produces the malcontents, the industrial hobo, the I. W. W. The second creates intelligent, contented citizenship, the only hope of a democracy.

THE PHYSICIAN IN INDUSTRY.

To men who are attempting to fit their enterprises to this latter classification, to men who are seriously at work solving the problem of the human potential in industry, permit me to say, that most of them are overlooking the possibilities for service that the socially minded physician may render employers and employees. The proper place has not yet been accorded him. He has not been given an opportunity to make one for himself. It doesn't count for much if surgeons are employed in a plant to care for the injured. The surgeon is in just the same relation to a business and the employees as is the electrical repair man who replaces the fuse and looks after short-circuits. What is needed is a doctor, a combination general repair and safety engineer, to look after the human machinery, to study stresses and strains on it, to give warning of a probable breakdown, to advise easing up on the load until the human mechanism has been readjusted, to do the hundred and one things that make for comfort of mind and body.

COST OF ILLNESS TO CAPITAL AND LABOR.

When we are told by investigators that only one industrial worker in five in need of a physician calls one, we may know what this shortsightedness in them is costing in lost time. We may also know what great service the industrial dispensary may render.

The loss of wages to the worker on account of preventable illness runs annually to the billion dollar mark. To the employers the loss must surely be twice that amount when we remember what a large part bad health plays in inefficiency, in irregularity of attendance, with its consequent poverty and low standard of living, in its frequent shifting from job to job, in its undermining of character and stability, in inducing alcoholism and other vices. The man struggling against a physical defect uses up every ounce of energy and loyalty to support his family. Can he have any loyalty left? Is it human to expect it?

Are we going to meet this great medical and economic question by the general introduction of the physician in industry or are we going to sit idly by and permit the propagandists to persuade our legislators that compulsory sickness insurance alone will assure every worker adequate medical service. I personally disbelieve that compulsory sickness insurance will produce that result, but this legislation is inevitable, unless industry grasps its opportunity and shows society that it is willing to undertake a method of health insurance through its own dispensaries, whose costs will be negligible compared to compulsory sickness insurance, and whose results for national health will be infinitely greater. If business isn't big enough to see the social and economic advantage of some system of self-imposed compulsory medical supervision of employees, then some of the most staunch opponents of compulsory sickness insurance will have to become its active proponents.

The industrial dispensary will lessen disease, increase the number of working days as well as working capacity and thereby increase the purchasing power for adequate medical service for the families of the workers. Medical care in industry is not a charity. It pays the best dividends of any department in business. It secures a new arm to the health department and makes possible preventive medicine on a scale yet undreamed of. Witness the reduction of 75 per cent. of the lost time on account of illness in the employees of the Norton Company, who use the medical department. In attacking directly such problems as personal hygiene, bad housing and living conditions, alcoholism and venereal disease, it will make a real contribution to national health and social welfare. It will immediately help cure the legislative mania with which the American people are cursed.

Free Gas Mantles in England

A CURIOUS situation has arisen at Scarborough in connection with gas mantles, says *Municipal Engineering and the Sanitary Record*. While local dealers are compelled to supply mantles at prices considerably above those which prevailed in pre-war days, the Scarborough Gas Company undertakes to supply and fix free of charge the best quality upright or inverted mantles at one penny each. It is explained that although the cost to the company of each mantle is 3½d., the loss that would be incurred would be made good out of the profit derived from the production of the benzol extracted from the gas at the request of the Government. The dividend of the company being limited to 5 per cent, any additional profit only benefits the consumer.

Fustic

An Important Dye Wood

By C. D. Mell

DYE WOODS constitute a class of forest products which once ranked very high commercially, and although the artificial coal-tar dyes have, in a large measure, replaced the natural dyes, a few of the dye-yielding woods are still being exploited on a commercial scale. The color obtained from fustic, for instance, is adapted particularly for the dyeing of khaki shades, and is considered by some to be superior to artificial dyes. What was at one time a great industry in many parts of tropical America has since shrunk to relatively small proportions. The West Indian and Central and South American fustic industry is, however, still a factor in the world's commerce, and it is believed that the yellow dye obtained from this wood will never be replaced entirely by the artificial dyestuffs. In fact, the shades of yellow obtained from fustic wood are at present in great demand, because the uniforms of our soldiers, as well as the cloth from which the tents are made, are dyed with fustic extract.

A normal specimen of the fustic tree as it appears in the forest

The greatly increased importation and use of fustic, and its consequent rise in price during the last three years, has resulted in a number of inquiries regarding this wood. The need of a complete popular discussion of the more noteworthy facts relative to this tropical product has long been felt, and, therefore, the purpose of this article is to describe briefly the general characters of the fustic tree, its nomenclature, distribution, importation of the wood and its uses.

Fustic wood comes from the fustic tree that is known botanically as *Chlorophora tinctoria*. The generic name, *Chlorophora*, is derived from the Greek words *chloros*, meaning green, and *phoro*, to carry, having reference to the green or yellowish coloring principle which the heartwood of this tree contains. The specific name *tinctoria* was given to this tree on account of the color-yielding property of the wood. The genus *Chlorophora* belongs to the mulberry family (*moraceae*), which is a large group of plants comprising many important timber trees. The common mulberry (*Morus alba*) and osage orange (*Toxylon pomiferum*) are among the trees closely related to it.

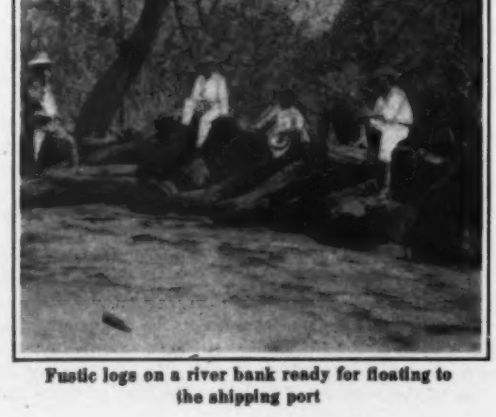
The tree has a good many vernacular names. It is known in English as dyer's maclura, dyer's mulberry, fustic, fustic mulberry, mora yellowwood, etc.; in French, bois jaune, b. a pian, maclura tinctorial, murier de Java, m. a rameaux epineux, and m. des teinturies; in German, farber-maclura, farber-maulbeerbaum, fustickbaum and farbender maulbeer. In Cuba the tree is known as fustete, mora del pais, mora blanca and fresno de America. While the above names are given to the tree, the trade recognizes the wood under many different designations. The color has given this wood a name in many different countries. The German name is gelbholz; the Dutch, geelholz; the French, bois jaune, and the Italian, legno giallo; all these names imply yellow wood. In addition to these there are many other less familiar trade names applied to fustic wood, a list of which may be of interest to many:

English	*French*	*German*
Fustic	bois de Bresil jaune	Alter fustic
Fustick	bois jaune	Fustik
Old fustic	bois jaune de Bresil	Brasilianische gelbholz
Mulberry	bois jaune de Cuba	Bresilienholz
Cuba wood	bois jaune de Fernambouc	Cubanholz
Yellow wood	bois jaune des Indies orientalis	Fiselholz
Mora	bois jaune de Tampico	Fisetholz
	Fasteque	Fustetholz
	Fustique	Fustikholz
	Vieux fustic des Anglais	Gelbes brasilholz
		Gelbes brasil eichenholz
		Gelbholz
		Jamaikaholz
		Querzitron

Spanish	*Dutch*
Fustete	Bastaardgeelhart
Mora	Stokvischohout
	Citroenhout
	Geelhout
	Verwer-moerbeessen

Some confusion has arisen in the name fustic from the fact that there are two kinds; one is called old fustic and the other young fustic. The former, or old fustic, is the West Indian species under discussion, while the latter, or young fustic, is the Venice sumac (*Cotinus cotinus*), which is a small, shrubby tree of a totally different kind. The cause of this misnomer is supposed to have been brought about by the fact that the Venice sumac was called fustet in France and was known and used there as a dye wood long before the tropical American fustic was shipped to Europe. When at a later date the dyers became acquainted with the American variety, they gave it the same name, but made a distinction by calling the Venice sumac, young fustic, and the American product, old fustic. Botanically there is no ground for this nomenclature.

The fustic is a medium-sized tree, rarely attaining a height of over 65 feet and a diameter of over 30 inches at the base. The trunk is of a brownish-gray color, generally quite smooth on young trees. Both trunk and branches are sometimes beset with spines. The crown is generally quite open and somewhat spreading. The leaves are rather small, rarely over four inches long, petiolate and alternate on the twigs. The flowers are small and the fruits consist of small, dry nutlets surrounded by the persistent parts of the flower. The tree may be recognized by the presence of a slightly glutinous milk of a sulphurous color. The range of growth of this tree is rather extensive. It is found growing abundantly in the lowlands of Mexico, from Tampico southward, and is more or less abundant on the east and west coast of all of Central America. It does not grow on the highlands. It is common in Columbia and Venezuela, but the species growing in Brazil are somewhat different, not only in their botanical characteristics, but also in the dye-producing qualities of the wood. True fustic has been reported from practically all islands of the West Indies. On some of the larger islands, as Cuba, Jamaica and Haiti, it is exploited and forms an important article of export. The tree thrives in almost any soil that has sufficient moisture. The commercial supply of the wood is now obtained chiefly from Mexico (principally Campeachy), Honduras, Nicaragua (west coast), Costa Rica (west coast), Panama and Venezuela. Smaller quantities are drawn from Cuba, Jamaica and Haiti.



Fustic logs on a river bank ready for floating to the shipping port

The tree is common in the lower belts of both the Atlantic and Pacific sides, but it attains its best development on the west coast south of Mexico. In Cuba it may be said to be ubiquitous and quite abundant in the rich valleys and fertile mountain slopes, where trees four and five feet in diameter occur. It always prefers, however, the proximity of the seashore and the well-drained banks of the rivers and streams. Like most of its associates, the fustic tree does not grow in dense stands like our pines or oaks in the temperate

A close view of a tree showing the character of the trunk and bark

climates. From one to two trees to the acre is a fair average. The fact that they are so scattered, and so many of them remain comparatively small, does not make the exploitation of fustic a profitable undertaking. This is true particularly in regions far removed from water transportation.

All the trees are felled by means of an ax. After felling, the trunks and larger branches are cut into four to six-foot lengths, after which all the sapwood, which is nearly white and from one to two inches thick, is removed. The heartwood is the only portion available for making a dye, and for this reason all the sapwood must be carefully cut away from the heartwood. The latter is bright or sulphurous yellow, which soon turns darker on the surface upon exposure to the air and light. The logs when ready for the market vary from a few inches to two feet or more in diameter. The value is in proportion to the size of the logs, the largest being regarded as the best. The wood is hard and heavy, weighing about 50 pounds per cubic foot. Being hard and very compact, the wood is almost indestructible and is used for many purposes besides that for dyeing.

The transportation of these logs from the stump to the place of loading on the boats is the most difficult part of the work. The tracts on which the wood is cut are almost invariably without roads and the logs must be hauled for many miles over the roughest country to the rivers. About a ton of fustic logs is loaded on a two-wheeled cart, to which is hitched a yoke of oxen. In many instances it requires from two to three days to bring a ton of wood to a suitable landing place on the river for transportation to a point where it can be loaded on ocean steamers.

The history of the use of fustic wood dates back to the middle of the seventeenth century. In 1840 England consumed 6,000 tons, valued at from $40 to $60 a ton. In 1860 she consumed 8,000 tons, valued at $200,000. It will be seen from these figures that the price per ton 75 years ago was even higher than it is at the present time in the United States. The subsequent decrease in price was due directly to the fact that other woods with similar properties came into use, and also chiefly because of the introduction of the synthetic dyes.

Just before the war fustic wood was cut, hauled and delivered alongside the ship at source of origin for about $8 or $10 a ton, or even less. After adding freight, insurance, lighterage and other charges, the wood was sold in New York at figures ranging from $20 to $25 a ton. Since the beginning of the war fustic has greatly advanced in price. The cost of getting the wood out of the forest has gone up considerably. The freight rates, insurance and cost of handling after discharging the cargo has nearly doubled. The profits to the dealers have almost vanished, because there is a limit to the price dyemakers can afford to pay. Fustic is now selling around $40, and some of the best lots have brought as high as $50 a ton, which represents an increase of about 250 per cent. over the price of four years ago, when occasional lots of fustic were sold for less than $20 a ton.

In 1905 only 4,371 tons of fustic wood entered the United States ports, while during the year ending June 30, 1916, 17,469 tons, valued at $289,913, were imported. This represents the largest quantity and value imported in one year in the history of the industry.

Fustic is imported almost invariably in the form of logs, very rarely in the chipped or ground condition. Before the wood goes to the dyer it is always chipped and then reduced into a fine state or powder and put into bags. From this material an aqueous extract and paste, or lake, are produced. When a strong decoction of the wood chips is prepared, the color is of a reddish yellow; when diluted it takes on an orange yellow color. The coloring principle (*maclurin*) is given off very readily to water. Upon the addition of acids it turns to a paler yellow, and the metallic salts throw down a precipitate of a yellow or greenish yellow tint. The chips are often employed for dyeing by keeping them in bags in the bottom of the bath, or the dyeing vat. The decoction gives to the goods, without any other preparation and without mordants, a yellow color with a dull brownish cast, and yet it is sufficiently permanent in the air. The mordants, alum, tartar and the muriate of tin, fix it and render its color lighter; the muriate of soda and the sulphate of lime render it darker. It is said to afford the same gradations of shades as well, and is considered as one of the most useful ingredients in dyeing; the color it imparts is permanent.

Fustic dye has been used for many years for coloring yellow, and it is now employed extensively with the appropriate mordants to produce shades of yellow, brown, olive and green. It forms the principal ingredient in dyeing greens upon silks and woolens. According to Napier light cotton fabrics, such as gauzes and muslins, are also occasionally dyed green by fustic. For this purpose the wood is used in the same manner as the quercitron. Fustic is also used with other woods for compound shades, such as drabs, fawns, olives, etc., and is used also with logwood in dyeing black, both on cotton and upon silks and cottons.

Chemical Differentiation of the Central Nervous System in Invertebrates*

By A. R. Moore

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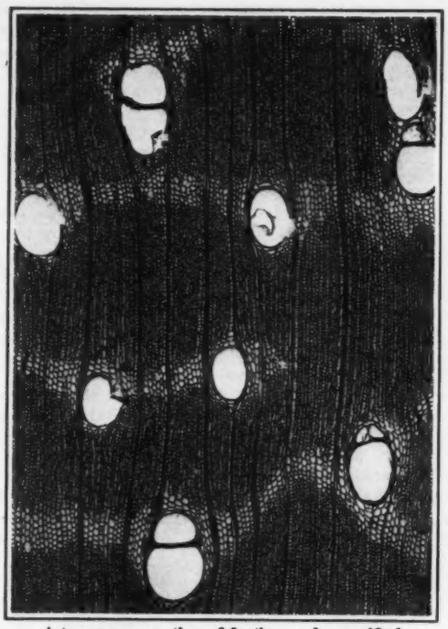
THE selective action of drugs for certain tissues forms the basis of the science of pharmacology. The action of such substances as strychnine in increasing the sensitivity of the sensory-motor junctions of the spinal cord is definitely known. In a more general way the selective affinity of caffein, camphor and atropin for specific parts of the vertebrate central nervous system has been established.

As an instance of the application of this method to the study of the nervous systems of other forms, Baglioni[1] has attempted an analysis of the cephalopod ganglia by means of strychnine and phenol. Strychnine was found to be specific for the cerebral ganglia and phenol for the mantle ganglia.

The writer recently has found that freshly hatched squid (Loligo pealii) furnish excellent material for demonstrating reactions of the type under discussion.



A transverse section of fustic wood magnified 500 diameters

These little animals show a delicate sensitivity to the action of the substance used. Their response to stimulation is easily demonstrable in the muscular convulsions of tentacles, neck and mantle, and the spasms are in every case, except where specifically inhibited, accompanied by a striking play of the chromatophores. The cephalopod chromatophore is a globular sac containing either yellow, red or brown pigment. At rest these bodies appear as small dark spots, scattered inconspicuously over the surface of the mantle, head and tentacles. Muscle fibers attached radially to the chromatophore control its form. Contraction of these fibers stretches the sac into a sheet, so that the surface of a given chromatophore may be increased a hundredfold by this mechanism.

The result of strong stimulation, such as mechanical injury or the action of potassium chloride, is a series of clonic spasms of the entire musculature, invariably involving extreme extension of the chromatophores. The play of brilliant color may therefore be used as an indicator of stimulation. If the precaution is taken to view the animals against a white background, the reaction can be followed with the naked eye.

In carrying out an experiment, a half dozen freshly hatched squid were put into a Syracuse watch glass containing a solution of the substance to be tested. In sufficiently dilute solutions the characteristic effects could be followed for an hour or longer. A strychnine sulfate solution (1:100,000) maintained the squid in a highly sensitive state for over an hour, so that a slight jar was sufficent to throw the animal into spasms and bring on the play of chromatophores over the entire body.

When put into caffein solution (1:10,000) juvenile squid show rapid circus movements. The circular character of the course is due to the cramped bending of the neck. The tentacles also show convulsions. At the same time a lively expansion of the chromatophores takes place in the entire head region and solely in this region. Only rarely may the display extend to the mantle.

In sea water one-sixth saturated with camphor gum, the reaction of young squid is exactly the reverse of that in caffein. While the head and tentacles remain passive and their chromatophores closed, the muscular spasms and the play of color take place in the mantle. The fact that the camphor acts directly on the mantle (stellar) ganglia may be demonstrated in the following way. With the stroke of a sharp scalpel sever the head from the body of the squid. In a few seconds the results of mechanical stimulation have abated and both parts are at rest with the chromatophores closed. Now put the two parts of the animal, head and body, into the camphorated sea water. The mantellar region shows muscular convulsions and the brilliant play of chromatophores, while the head and tentacles remain quiescent unless stimulated directly.

Juvenile squid immersed in atropin sulfate solution (1:2500) show abnormally rapid swimming movements, soon followed by failure of locomotion. The animals lie on the bottom of the dish and with the microscope one may see the spasmodic contractions of the tentacles and mantle. There is no play of the chromatophores. This fact distinguishes atropin spasms from those due to strychnine, caffein and camphor. It may be that the failure of the radial muscles of the chromatophores to contract is due to the blocking of the impulses to these muscles. In such a case we would have an analogy in the action of atropin in paralyzing the terminations of the sympathetic in vertebrates.

Crustaceans are far less favorable material for the study of the selective action of drugs. This is undoubtedly in part due to a failure of the substance used to penetrate the tissues. The writer has shown that certain fresh water crustaceans are rendered more sensitive to light by treatment with solutions of strychnine, atropin and caffein.[2] Striking results may also be obtained in marine forms with saturated solutions of camphor gum. Specimens of the hermit crab (Pagurus longicarpus) after a few minutes' immersion in the solution of camphor gum in sea water are seized with tremors at each attempt at locomotion. This is due to the fact that all the appendages are thrown into convulsive trembling movements resembling the symptoms of palsy in human beings. Similar effects may be observed in the marine shrimp (Crangon vulgaris). In this form the thoracic appendages first show tremors, then complete paralysis. The swimmerets are next extended at right angles to the median line of the body and show continuous tremors. At this stage the animal, when stimulated, invariably swims forward, and is entirely unable to move backward. This is due to the fact that the swimmerets are able to make only the stroke which carries the animal forward. This fact may indicate that camphor acts selectively on the ganglia of the abdominal nerve cord, paralyzing the motor elements which control backward swimming, and rendering more sensitive the nervous elements controlling forward movement. Eventually complete paralysis supervenes.

Further tests were made to determine the character of the action of strychnine, atropin, caffein and camphor on starfish (Asterias), medusa (Gonionemus) and the sea anemone (Metridium). In the case of medusa and sea anemone, atropin alone was an effective reagent in increasing the animal's sensitivity. A sea anemone put into atropin sulfate solution (1:2000) upon stimulation withdraws the tentacles, contracts the sphincter, and spasmodically contracts the longitudinal muscles. The animal does not fully recover the relaxed condition in the atropin solution, but revives in a few minutes in a stream of fresh sea water. Specimens of medusa put into atropin sulfate solution (1:2500) contract their tentacles and show continuous activity of the bell with an abnormally high rate of pulsation. Starfish were affected by atropin in the same way as by strychnine.

These results indicate an increased chemical complexity of the central nervous system developing *pari passu* with an increase in morphological complexity. Thus, in the actinian and coelenterate where the diffuse nerve net system obtains, strychnine, caffein and camphor exert no excitatory action. With the development of localized nerve tracts and the beginning of a central nervous system in the asteroids, strychnine, in comparatively high concentrations, produces its characteristic effects. In crustacea and the cephalopod mollusca with their highly developed central nervous systems, the strychnine is, as we should expect, effective in low concentrations. Caffein and camphor act as excitants only where the histological elements of the nervous system are completely elaborated, viz.: in crustacea and the cephalopod mullusca.

Atropine stands in a separate category, since it is effective as a nerve excitant in members of all the classes tested. It would seem, then, that atropine forms a compound with a fundamental constituent of all the nerve cells, while strychnine, caffein and camphor combine with neuronic molecules which are the products of a higher organization.

Summary.—As evidence for the chemical differentiation of the central nervous system in invertebrates, it has been shown that, in the cephalopod (Loligo pealii), caffein brings about hyperirritability of the cerebral ganglia, while camphor affects the stellar ganglia alone in the same sense. Atropin causes spasms in the squid, but inhibits the activity of the chromatophores.

Camphor shows a selective action on the central nervous system of the shrimp (Crangon vulgaris) paralyzing the elements which function in backward swimming movements and exciting those controlling forward movement.

Atropin increased the sensitivity of all the forms tested.

* Proceedings of the National Academy of Sciences.

[1] Baglioni, S., *Zs. allg. Physiol.*, 5, 1905, (43-65).

[2] Moore, A. R., *Science, New York*, N. S., 38, 1913, (131-133).

Marine Engineering from 1911 to 1917*

MR. HALL-BROWN, in his admirable presidential address to his institution in 1911, reviewed, in a very complete manner, the progress made in marine engineering to that date, so far as it related to the merchant service. It may, therefore, be both interesting and instructive to continue the narrative. While not very remote in time, that period is, perhaps, rather distant in effect, and the manifold changes that have taken place permit, I think, of my traversing this subject, with the hope of exhibiting fresh features and of indicating new and interesting problems.

THE MARINE STEAM TURBINE.

At the commencement of the period under review the steam turbine had become established for the purpose of marine propulsion, but its utility at that time was confined, more or less, to fast high-powered ships. It had proved its superiority over its old-fashioned opponent by its somewhat greater economy, its saving in space, and the ease with which the necessary high powers could be generated. The main development in this phase of its application was the increase, which it made possible, of the limiting powers and speeds of fast vessels; and full advantage was rapidly taken of this opportunity in warships and in ocean liners.

Propeller and turbine revolutions are always in opposition, and this perpetual antagonism becomes the more pronounced the more moderate the power. The essential compromise involved in the simple turbine arrangement must, then, have a limit of efficacy, and below a rough value of about 18 knots the superiority of the turbine drive could not be demonstrated. At decreasing speeds the reciprocating engine had an increasing advantage over the simple direct-coupled type, which would have left it supreme for moderate and slow-speed vessels, had turbine applications been arrested in their original form.

THE "COMBINATION" SYSTEM.

But a ready realization of the relative dependence of the two types on their condensing plant, *i. e.*, their respective abilities to utilize the heat energy of the steam at the lowest pressures, soon led to the introduction of the well-known "combination" arrangement, a hybrid grouping of the opposing systems, wherein reciprocating engines coupled to the wing shafts exhausted into low-pressure turbines on the center shafts, at about atmospheric pressure. The result obtained was a distinct improvement over either of the two methods used alone. The arrangement was specially applicable for moderate powers, such as required by the intermediate class of liner, and for that purpose has been largely used within the last ten years. Viewed in the light of subsequent advance, however, such a conjunction of dissonant elements could only mark a transient phase in a period of development—a partial surrender forced on the established order of things by the inherent power of the new. For this grouping of unlike things was naturally unstable, and had ultimately to give way to the virile attacks of a newer order, possessed—as it has shown itself—of many potentialities of sound growth.

In the slow cargo "tramp" vessel the reciprocating engine results could not be approximately attained by the simple turbine arrangement; the latter was never even considered as a feasible alternative. And when we realize the great proportion of pure cargo vessels in the mercantile shipping of the world, we understand what a wide field of employment was herein closed to the turbine—permanently closed, unless some great step could be made to render it practically applicable. These considerations, then, leave us with the general impression that about a decade ago the reciprocating engine had given place to the direct turbine for warship, fast liner, and channel types; had compromised with it for vessels of the intermediate class; and had refused to recognize it as having any claims on that extensive class comprising the low-speed types.

THE GEARED TURBINE.

But, even while these conditions obtained, the solution to the problem of achieving the general applicability of the turbine had come into view. It was, of course, the logical issue of the fundamental disagreement between propeller and turbine revolutions that a system of power transmission between primary and propeller shafts should be adopted. The natural method was that of mechanical gearing; and, despite the difficulty of believing that gearing could be made to fulfill the severe requirements of such an application, the result is seen in the remarkable development of the geared turbine arrangement, its well-proved qualities, and the supreme position it holds today.

Ten years ago it was in little more than its embryonic stage; about three years later it had reached the experimental stage; then rapidly followed its promotion to the proposal lists and the stage of tentative application by the more courageous; until now we find it occupying the proud position of the standard type, demonstrating its universal application by the rapid displacement of the direct-coupled turbine, the combination system, and the reciprocator from the respective positions in which they had established themselves. Its superiority over all these types, in the essentials of economy, weight, and space, is unquestioned; and its reliability is at least as certain. It has been extensively tried under all kinds of service conditions, and competitive systems will undoubtedly find it difficult to attain to the all-round excellence of its performance.

Concurrently with the development of this mechanical system we find the growth of the rival methods of hydraulic and electrical transmission. Each system has its own particular advantages—clearly set out by its advocates—over the geared type, but neither can meet it on the all-important grounds of economy and general applicability. The mechanical system at present makes the pace, and that pace seems likely to be rather too severe for the other forms. The relative proportions of new shipping that embody the three types is highly significant of their respective advantages, and of the appeal which they make.

Type of Ship and Machinery.	Relative fuel consumption.	Relative machinery weight.	Relative superficial areas.	
			Engine Room.	Boiler Room.
1. FAST OCEAN LINER.				
(a) 4 S. triple series direct-coupled turbines; cylindrical boilers—saturated steam	100	100	100	100
(b) 2 S. single geared turbines; cylindrical boilers—saturated steam	89	93	90	92
(c) 2 S. single geared turbines; cylindrical boilers—100° F. superheat	84·5	93·5	90	86
(d) 2 S. double geared turbines; cylindrical boilers — 200° F. superheat	75	88·5	86	77
2. INTERMEDIATE LINER.				
(a) 3 S. combination machinery; cylindrical boilers—saturated steam	100	100	100	100
(b) 2 S. single geared turbines; cylindrical boilers—saturated steam	93	80	87	92
(c) 2 S. single geared turbines; cylindrical boilers — 100° F. superheat	89	81	87	91
(d) 2 S. double geared turbines; cylindrical boilers — 200° F. superheat	74	72	83	80·5
3. CROSS-CHANNEL STEAMER.				
(a) 3 S. compound direct-coupled turbines; cylindrical boilers —saturated steam	100	100	100	100
(b) 2 S. single geared turbines; W.T. boilers—saturated steam	91·5	75	100	97
(c) 2 S. single geared turbines; W.T. boilers—100° F. superheat	86·5	76	100	97
(d) 2 S. double geared turbines; W.T. boilers—200° F. superheat	73·5	68	96	86
4. CARGO STEAMER.				
(a) S.S. triple-expansion reciprocating engine; cylindrical boilers—saturated steam	100	100	100	100
(b) S.S. single geared turbines; cylindrical boilers—saturated steam	83·6	79	85	95·5
(c) S.S. single geared turbines; cylindrical boilers — 100° F. superheat	79	79·5	85	94
(d) S.S. double geared turbines; cylindrical boilers — 200° F. superheat	66	72·5	80	87·5

Comparative Figures for Different Steam Machinery Types.

But gearing in its rapid advance has hardly halted at the single spur and pinion drive. We now have the double arrangement coming largely into use, as the outcome of the success of the original form. This apparently minor development is obviously the special demand of the slow-speed ship, wherein the reduction ratio for suitable revolutions is very large; but it is not to be supposed that its utility is confined to the low-power low-revolution equipment. It can also with considerable gain in weight and efficiency be applied to high-powered vessels, as we shall see immediately. The great improvement due to double gear is mainly derived from its reaction on the permissible propeller revolution and from the turbine equipment, the different elements of which can be arranged for their respective limiting speeds, and form compact units of insignificant dimensions compared with those of earlier days.

SUPERHEATED STEAM.

In coincidence with all these changes, there has been a marked revival in the marine use of superheated steam. The continuous improvement in economy has led to a continual effort after further gain—the usual effect of successful thrift—and the diffidence in facing the troubles of high temperature steam has vanished before the bright prospect of augmented profit. In land power plants, engineers have successfully used relatively high superheats, and are now tentatively approaching extreme high-pressure high-temperature conditions. The marine engineer is more seriously restricted, however, and a less riotous advance will require to satisfy him.

And so we find, all well within this decade, the reciprocating engine and the direct turbine—separately, and in combination—achieve the zenith of their excellence, become stayed, and then supplanted by the rapid development of the geared transmission system; which, whilst imbuing the turbine with new powers and perfections, incidentally renders it a more appropriate vehicle for the safe carriage of that vexatious but profitable medium—superheated steam. The latest achievement of this period of restless progress in steam-propelling machinery is the superheat-geared-turbine equipment, transcending its forerunners in practically all respects, and marking an epoch of advance without equal in marine engineering history.

COMPARATIVE FIGURES FOR DIFFERENT TYPES.

A consideration of this advance on an arithmetical basis, by an examination of tabulated average figures for different types of vessels, may therefore be instructive. These are given in the accompanying table. For all types case (a) denotes standard designs of 9 or 10 years ago; (b) and (c) are present geared proposals with saturated steam and with 100 deg. Fah. superheat respectively; and while (d) is only so far actually utilized in type 4 it has been embodied in the others because of its possible and very probable application thereto. The figures are based on the reaction type of turbine, but roughly similar results may be expected for other systems. As will be seen, no consideration is taken of the hydraulic and electrical forms of transmission, for, apart from the difficulty of obtaining reliable figures for these, their practical test has been less extensive and severe, and consequently they are not yet on the same level of proved excellence. It must be understood that, since actual construction varies with service conditions, these figures only represent fair averages; but the guidance they provide may be considered sound.

THE OIL-ENGINED SHIP.

No summary of recent progress in the mercantile service could fail to include the advent of the oil-engined ship, made possible by the gradual evolution of the Diesel type of engine. A considerable amount of experience has now been gained, and in the cargo boat to which its application is still limited, it has demonstrated many advantages and perhaps disclosed a few faults. The problem, again, is that of the relation between coal and oil in supply and price. In particular cases, with fixed routes, the oil may be available; but the oil engine could scarcely yet be considered a suitable equipment for a freight ship with a roving commission. Apart from the necessity of available supply, the oil engine is not yet so developed that it can use any kind of oil.

At the time of its original projection into marine work, it had to meet only the reciprocating steam engine with its heavy machinery and consumption of anything over 1½ pounds of coal per horse power per hour. It was, therefore, easy to demonstrate its advantages in comparison therewith, but with the development of the highly efficient turbine gear-drive this demonstration becomes of greater difficulty. Again, the employment of the oil engine is at a certain sacrifice of propulsive efficiency, as the revolutions at which it is run are not quite suitable for the slow-speed ship. Of course, geared transmission could be used as for the turbine, but this entails added weight, with a consequent reduction of its advantages. The hydraulic type of transmission would also seem to be quite applicable, and has been used in this connection.

As an example for comparison, take a ship fitted with a 2,000 b.h.p. motor, assumed to be bunkered for a 20-day voyage with a few days' reserve of fuel and, alternatively, fitted with double-geared-superheat turbines of much lower propeller revolutions, and, consequently, of lower shaft horse power. The gain in machinery weights would be a very small amount in favor of the oil ship—about ten tons, but the difference in fuel weights would be much larger—about 490 tons of coal, against 250 tons of oil. The total increase in carrying capacity is therefore about 250 tons; and when other minor differences are allowed for, such as wages, bills and the costs of lubricating oil and stores, there would be a gain per voyage of about £150 for the motor ship, exclusive of the respective costs of fuel. The relationship between the respective costs of fuel per ton is,

* From the Presidential Address of Mr. Alexander Cleghorn, before the Institution of Engineers and Shipbuilders in Scotland, on October 23, 1917, as reported in *The Shipping World*.

therefore, fixed, if the same overall economy is to be attained in each ship, and is approximately—for coal at £1 per ton, oil must cost not more than £2 10s. per ton. If, however, the oil ship were bunkered for the round voyage in place of the half voyage only necessary for the steamer, the gain from additional cargo would hold only on the half voyage, and in this case the oil should not cost more than £2 5s. per ton.

These figures are, of course, only approximate. The question is further complicated by the relative first costs of the ships, depreciation allowances, repair bills, and the respective periods necessary in dock for repairs; but it will be seen that the two types of machinery may not be unevenly matched on the whole—except, perhaps, as regards running troubles, of which the oil engine still possesses its full share. No doubt these difficulties will be overcome in time, and under the progressive policy which is being pursued by the British Marine Oil-Engine Manufacturers' Association, rapid development may be expected. Progress, however, up till now, has been slow, and it must be accepted as the present condition that, even in those cases to which the Diesel engine is particularly applicable, it is on no more than an equal footing with the modern steam plant.

MECHANICAL, HYDRAULIC AND ELECTRICAL TRANSMISSION SYSTEMS.

The dominant influence of the evolution of transmission systems on the recent advances in marine propulsion has been alluded to. Of the three systems advocated, the geared type is pre-eminent, the hydraulic and electrical forms laboring under the heavy disadvantages of lower efficiency, a greater complexity, and a distinctly more limited applicability. The latter systems, however, possess features of value that render them suitable in certain spheres. Both, for instance, allow of the abolition of the astern element and give, in addition, a higher reversing power than is usual when

Machinery Type.	Turbines with Double Mechanical Gearing.	Turbines with Hydraulic Transformer.	Turbines with Geared Electrical Generators and Motor-driven Screws.
Superheat	200° Fah.	200° Fah.	200° Fah.
Propeller revolutions	90	140	90
Turbine revolutions	2,400 & 1,500	About 1,000	2,400 & 1,500
Transmission efficiencies	·965	·92	·885
Relative fuel consumption	100	123	109
" machinery weights	100	109	108

Comparison of Mechanical, Hydraulic, and Electrical Transmission System for a 20,000 h.p. Ship.

dependence is placed on a special turbine. This elimination has an important bearing on the superheat problem. The hydraulic transformer—associated with the name of Dr. Föttinger—would seem also to offer an appropriate reducing system for oil engine work, the form, in effect, being that of a highly flexible coupling. It can be easily arranged for reversing, and thus permits the engine to be simplified. At low powers the transformer has the same objection as gearing, the reduction ratio being a fixed one, and specially geared cruising turbines are therefore required if efficiency at low speeds is essential.

With the electrical system the advantages under such conditions are more apparent. Economy at fractional powers may be obtained by cutting out units of the main turbo-generators and supplying all the propeller shaft motors from one or more generators running at or near full power efficiency. Thus, at cruising speed, a large portion of the main machinery is at rest, and is therefore in direct contrast with the actual increase of moving masses by the use of cruising turbines. Again, a breakdown of a main element does not cut off power from a corresponding shaft, since there is no difficulty in arranging for supply from any generator. On the whole, the features of this system, which involve a double transformation of energy and the inherently large losses resulting therefrom, heavier machinery, the necessity to safeguard it from water, and the requirements of special ventilation, combine to create but an unconvincing appeal.

To obtain an indication of the respective merits of the three systems as applied to merchant work, an approximate estimate for a 20,000 h.p. ship was made, and the subjoined table gives a relative summary of the results. The double-geared turbine is taken as standard, and 200 deg. Fah. superheat is used for all. The electrical system is arranged for geared generators, thus placing the turbines for these two systems on a similar level, except as regards the astern elements. The propeller revolutions can also be alike—namely, 90 per minute, and the same secondary horse power is taken. With the hydraulic transformer the propeller revolutions are increased, owing to the moderate reduction ratio permissible. This entails heavier turbines, and a higher secondary power, notwithstanding that the transformer is credited with a ratio of about 7 to 1, which is perhaps higher than has been used. The assumed transmission loss of 3½ per cent. for the gear is probably severe. The 8 per cent. loss for the transformer is, on the other hand, low, but is used to cover, also, the possible gains due to feed water heating and absence of astern turbines. The 11½ per cent. loss for the electrical arrangement is an estimate only, and includes the astern gain. It will be seen that on both counts of fuel and weight the all-geared arrangement wins, and there is great probability that on a cost basis the differences would be augmented.

The Mystery of the Transparent Rat*

THE story of the transparent rat at the South Kensington Museum, reported in the *Chemical News* of June 1st (CXV., 260), has created considerable interest, and to obtain more light on the subject, a representative visited the museum the other day, and asked Dr. S. F. Harmer, F. R. S., if he would be so good as to enter a little in detail in explanation of the mystery. Dr. Harmer was kind enough to do so, and at the same time to produce half a dozen such specimens—all transparent—rat, mouse, frog, fish, and so on.

Dr. Harmer has asked the Board of Trade to grant him a license to employ a German patent, 8621 of 1909, for producing such specimens, and the principle, as Dr. Harmer described it, by which the transparency is secured is the immersion of the specimen (after due preparation) in a liquid which has the same refractive index as the tissue which it is desired to examine, or else, more generally, the same refractive index as the mean of the indices of the various tissues of which the body is composed.

The principle may be illustrated by a glass tube. The tube from its surface ordinarily reflects lights and objects. Light rays are thrown upon it from various quarters. Placed in water, however, its aspect becomes much more transparent. Placed in a liquid having the same index of refraction as the material of the glass, the tube is hardly visible at all.

The body of an animal contains various cavities, the cavities occupied by organs. A ray of light passing through would be deflected at the surface of each new medium both where it passed in and where it passed out. This fact, together with the amount of dark coloring pigment in the body, has its bearing on the opacity of the object. Remove the dark pigment and place the body in a medium having the same index of refraction as its own, and the undoubted optical result is at once a considerable advance in the direction of transparency.

A good example, by the way, of the opaque result of bending rays of light out of the strain is "ground glass," in which the surface is so broken up that the separate rods of light do not pass through in a direct line at all. The glass, therefore, is not "transparent."

The effect of color pigment in a body was strikingly seen in the transparent rat, the first of the specimens Dr. Harmer placed on the table. The rat, with legs extended hangs immersed in an oblong glass vessel. He is singularly transparent. His skeleton is his most salient feature, but that, too, is transparent in a sense. The bony articulations of his tail at first take one's attention because of their detached regularity and the thin line on either side of the chain which marks the limit of his skin. His body, of course, has not the same water-like absence of color of the fluid. It has a yellowish look, as of something gelatinous, and in the thighs is a certain cloudy bluish opalescence. But the body, through the film which indicates it, is clearly transparent, and every bone is seen "in the round," with the organs reposing in the interior, as surely as when one opens a turkey on the kitchen table.

The ears the spectator must specially look for, or he would miss them altogether. They are more intangible than wetted goldbeater's skin, and hang over with the same clinging folds.

It is the liver, however, which shows what color means to this process. It is simply a large, inky, irregular mass, packed with black pigment, the one blot in the transparent scheme, and it declares in the most uncompromising fashion that indices of refraction have nothing to say to the blank opacity of dense color. This fact, then, is duly taken into account in the preparation of the body. All dark pigment, as far as possible, is removed, and the skin is bleached. The rat does not go into the solution wearing his fur overcoat. He has been reduced to the unaesthetic nakedness of the rabbit on the poulterer's slab.

He goes through more than one sea of solution before he draws up in the anchorage of the object glass. First, the water that the tissues naturally contain must be removed. All organic bodies carry a considerable proportion of water—the human cardiac muscle, for instance, 80 per cent.

One has to employ a series of fluids which mix, with water on the one hand and with oil on the other. The rat goes first into alcohol, weak. This is gradually strengthened till, all water expelled, the rat is in pure ethyl alcohol. A fluid must then be introduced which mixes equally with alcohol and with oils, and the rat comes eventually into pure benzol, in order to get rid of the alcohol. It is, of course, necessary to keep him in a state of being permeated by some liquid through all the stages, or he would collapse and lose his natural shape.

An air pump is brought into play, and he passes through a vacuum into the liquid with the same index of refraction as his own; and this henceforth (when the bottle has been sealed) becomes his home.

Something like the same process is employed in mounting slides for the microscope. If it is desired to mount a flea, the flea, being full of water, must be treated scientifically, and the water has to be got rid of before you can transfer him to the Canada balsam, the substance usually employed for mounting microscopic slides.

Equally, if one cut off a person's hand, the anatomist would treat it in the same way as the rat, in order to bring it to a state of eventual transparency.

An example of a liquid, the index of refraction of which corresponds to most of the animal tissues, is a mixture of three parts of salicylic methyl ester and one part of benzylbenzoate.

Various specifications of liquids with different indices of refraction are set out in a German booklet Dr. Harmer possesses, written by Dr. Spalteholz, the second edition of which was published in Leipzig in 1914, the year the war broke out. This is the "Uber das Durchsichtigmachen von menschlichen und tierischen Präparaten und seine theoretischen Bedingunge."

The professor gives the following—

	Index of refraction	Specific gravity
Wintergrunol (or oil of wintergreen)	1.538	1188
Safrol	1.542	1102
Benzyl-benzoate	1.570	1121
Isosafrol	1.577	1115

If the body which is to be made transparent has an index of refraction of, say 1.560, the appropriate solution would probably be a mixture of safrol and benzyl-benzoate, and experiment would determine the proportions.

Beginning with the lower, and adding a fluid of higher refractive index, he would see the object becoming progressively more and more transparent, and thus the experimenter would "focus" it.

"In some cases," Dr. Harmer quoted, "liquids may be chosen which, by virtue of their index of refraction, cause certain parts or groups of the body to disappear, so to speak, and thereby bring other parts more prominently into view."

Thus it is possible, if the anatomist is concerned only with the muscles, to arrange a solution with the same index of refraction as the muscles, and to ignore the different index of refraction of the bones, by means of which, in the result, the bones would be optically obscured in the specimen.

On the same principle, on the other hand, the bones can be brought principally into view. Professor Spalteholz gives several solutions for revealing human decalcified bone; for instance:

5 parts of oil of wintergreen and 3 benzyl-benzoate, or
3 parts of oil of wintergreen and 1 isosafrol, or
3 parts of safrol and 1 of benzyl-benzoate.

Dr. Harmer, going through his curious objects, produced an intestine in a case, the tissue almost invisible in the solution. The blood-vessels, by reason of an injected red matter, stood out like a network of coral. The circular tube of the colon might have been gossamer fabric of skeleton-leaf. One could see a cherry-stone traverse its entire length.

Dr. Harmer has also a transparent mouse and a transparent fish, the latter showing with fine definition the air-bladder and the rays of the fins along their entire length, so clear that they may be counted.

A frog, just coming to the surface, is another interesting "macragraph," and a larger case contains a tiny hand, arm, and shoulder-blade, the fingers extended, the bones of the forearm and clavicle shown separate and disjoined, and the muscles and arteries daintily outlined—the whole making a very beautiful and successful specimen.

* The *Chemical News*.

A First Aid competition meeting

Girls from the shop handle a difficult case

Safety in Industry

First Aid and Accident Prevention in a Great Manufacturing Plant

THE Third Annual First Aid Meet, held under the auspices of the Bethlehem Steel Company's Department of Safety and Welfare, on August 25, 1917, was a notable event in the history of first aid education as conducted by large industrial concerns of the country. Preliminary contests had previously been held at Sparrows Point, Md., and Lebanon, Pa., between department teams from the Sparrows Point, Lebanon, Reading and Steelton plants. Of these, twelve teams had qualified for the final contest at Bethlehem, none of them with a score below 98 per cent., and five of them with 100 per cent. records. The morning of the day devoted to the First Aid Meet on the athletic field at South Bethlehem was given over to preliminary contests between department teams representing the Bethlehem plants. Of the 70 Bethlehem teams entered in the preliminaries, 15 qualified to compete in the final contest with the 12 visiting teams.

In the preliminaries, the captain of each team drew three problems from a list of 24, the series of three determining the teams' places in eight groups on the field. Each team, consisting of a patient, captain and four other members, took its place on the field as indicated by the problems drawn, and the dressings and other exercises started and stopped promptly at the stroke of a gong. The dressings and equipment had been assembled in advance for each problem as specified and were promptly issued to the teams who were to use them. In general, the problems concerned the treatment of fractured limbs, burns, lacerations, asphyxiation, sunstroke and heat prostration.

In the final contest, the problems were drawn by the captains of teams which had qualified, in the same manner as in the preliminaries, and the execution of these problems together with a litter drill constituted the final test between the competing teams. Dr. L. A. Shoudy, chief surgeon of the Bethlehem plants, was assisted in the work of inspecting and quizzing the teams by a corps of expert physicians, including a number of officers from the training camp of the United States Ambulance Corps at Allentown, Pa. The final standing of all teams was determined by averaging the scores made in the preliminary and final contests. The three teams adjudged the victors in the final contest all came from departments connected with the Bethlehem plants, the third prize being awarded to a team composed of girls from the main office. In addition to the silver and bronze trophy, competed for annually, each member of the team winning first place, with a score of 100 per cent., received an American Red Cross bronze medal and a trip to the world's series baseball games; each member of the team reaching second place, with a score of 99.75 per cent., received $25 in gold and an American Red Cross certificate; while each member of the girls' team received $15 in gold and an American Red Cross certificate.

Motion pictures were taken of the various events in the First Aid Meet, the first showing of which was made at the Health Service Sectional Meeting of the National Safety Congress, in September.

At the Sixth Annual Congress of the National Safety Council, held in New York on September 14th, Mr. J. R. Mulligan, assistant safety engineer of the Bethlehem Steel Co. of South Bethlehem, Pa., read an interesting paper describing details of the methods followed at the various plants of the company. Abstracts from this paper, which appeared in "Safety," published by the American Museum of Safety, New York, are quoted as follows:

FIRST AID AND ACCIDENT PREVENTION WORK AT THE BETHLEHEM STEEL COMPANY'S PLANTS.

First Aid, as it is known at Bethlehem, is two-phase: First, training in that phase of first aid that rescues men from danger, gives artificial respiration, treats shock, applies tourniquets, binds up wounds or splints broken bones, and then hurries the patient to the doctor. Second, training in accident prevention—that most important phase of first aid work—which prevents injury to fellow-employes by knowing the hazards of the various operations and guarding against them. The training should go hand in hand, and especially so in view of the end to be attained—a fully qualified safety committeeman.

FIRST AID—ACCIDENT PREVENTION TEAMS.

The men are instructed in units designated as teams, one or more teams representing each shop or department. A team is composed of six regulars and two substitutes. One of the regulars is designated as captain and another as patient, all taking the full course and the substitutes filling in on team work in the absence of the regular members. Each team may have but one man who has previously taken the course, but he cannot act as captain in the Annual First Aid Meet. This committee man acts as team coach during rehearsal period and puts the men over the work given them by the regular instructor. The departmental teams are composed of the more intelligent men in the shop selected from the various work operations. About 25 per cent. of these men are foremen.

TRAINING IN FIRST AID WORK.

The course is, and necessarily should be, as simple as possible. With repeated drill on essentials, the thing to do and how to do it becomes more or less automatic when an accident occurs. Stress is laid upon the exercising of good judgment in cases of emergency. "Think, do the right thing first," is the motto.

The instruction is based on literature circulated by the Federal Bureau of Mines and other first aid authorities. Before taking up bandage and splint work, a very thorough but simplified course is given in anatomy, muscles, circulation, the vital organs and the nervous system—a review and practical application of the essentials of a course in physiology as given in the average grammar school. The instruction is made as practical as possible through the medium of pictures, charts and the human subject. A very sharp line is drawn between real first aid and the doctor's work. Simple names and terms are used. Medical terms are left for the doctor's use. The triangular bandage is used almost exclusively. Some training is given in roller bandage work to be used only in cases of sprains at joints and finger and toe injuries. In splint work the men are taught to pad the splints with cotton or other soft material and wrap in triangular bandages before applying to limbs—this detail to insure free circulation in the limb and also prevent consequent pain due to splint pressure.

The course covers a period of four months, two hours per week on company time, of which one hour per week is spent with the regular instructor and one hour per week in rehearsal under the supervision of a committeeman who has previously taken the course. At the completion of the course the graduating exercises take place in the form of the Annual First Aid Meet, in which all departmental teams participate.

TRAINING IN ACCIDENT PREVENTION.

You cannot qualify a man for safety committee work over night. Safety committeemen are not born. A man may be naturally careful and prevent accident to himself but he must be trained in accident prevention if we expect him to look out for the other fellow. Neither can we expect long service in the shop to qualify a man for accident prevention work; very often he has grown so familiar with danger that he does not see it for himself, much less point it out to his fellow worker. Men must be trained to see the causes and near causes of accidents in order to prevent them. Such training must come through a detailed study of the unsafe practices and hazards of the respective departments.

Safe practices covering the various operations are dwelt upon. Departmental accident statistics and accident investigation reports are used. Photographs and prints showing accident causes help in the work. Current literature is quoted on the subject under discussion and interchange of ideas encouraged. Much stress is placed upon the attitude and proper spirit of the committeeman in approaching a fellow-worker on accident prevention work, realizing that accident prevention through education is a persuasive, rather than commanding, proposition. A part of each first aid instruction period is devoted to this work.

Committee work in fitting the man to the job, night school education, athletics, recreation centers, caring for the injured, the sick and unfortunate—all plant activities involving the human element are within the realm of the safety organization. If the problem of the employer and employe is to be solved finally, the solution should naturally come through the medium of such a democratic organization—trained to be considerate and helpful each to the other.

RESULTS OF FIRST AID AND ACCIDENT PREVENTION WORK.

Some organized accident prevention work was done in the year 1914, but intensive training for this work was begun in September, 1915, and up to the present time 1,200 men, or about 5 per cent. of the working force at Bethlehem—one man in every twenty—have qualified as safety committeemen.

A study of the accident statistics at Bethlehem, covering the last three years of the unorganized accident prevention period—1911, 1912 and 1913—as compared with results or organized work covering the three-year period, 1914-1916, shows accident reduction as follows: Lost eyes, 33.65 per cent.; amputations, 41.5 per cent.; fatal, 10 per cent.; average reduction for all causes, 28.38 per cent. This reduction was effected despite the fact that accident causes were many times increased, due to war production activities.

THE SAFETY COMMITTEE ORGANIZATION.

The safety committee organization comprises the following divisions, or classes:

1. The permanent safety committeeman—one in each department. He has charge of all first aid—safety committee work in his department and is responsible for first aid equipment, safety bulletin boards and the

Girls from the offices do neat work

A team from the mills ready for action

distribution of safety literature throughout his department. He also makes written reports of accident investigations in his shop. He is under the supervision of the division safety inspector and is compensated at the rate of $5 per month for the detailed attention he gives this work in addition to his regular shop duties.

2. The department teams taking the course in first aid—accident prevention, and who qualify for this work by completing the course with the Annual First Aid Meet.

3. The active safety committeemen. This group assume their duties upon completion of the course and serve for one year, or until the next First Aid Meet. In company with the permanent safety committeeman they make an inspection of the shop once a month.

4. The general safety committeemen (once a committeman always a committeman) who have served for one year as active committeemen. They are auxiliaries of the active committeee, but do not make the monthly inspection of the department.

Drum-Fire

THE following is an abbreviation of a letter by Mr. G. F. Sleggs which appeared in the *London Times*. The conclusions arrived at are the result of eighteen months' experience at the front:—

There is a fundamental and peculiar difference between the sound emitted by a gun and that of an exploding shell. When the gun is fired the sound-wave produced is of a totally different nature from that produced by the burst of a shell. In the former case the impact of the gases leaving the muzzle, as it were, "strikes" the atmosphere in the direction in which the gun is pointed, but the burst from the shell causes a sound-wave of uniform intensity all around, as the gases emanating from the high explosive are not confined in any direction, as is the case with the cordite of the gun, the only escape being at the muzzle. Every soldier who has been to the front knows that if you stand in front of a field gun or naval gun whilst firing, even at a considerable distance (several hundred yards), the crack is painfully intense to the ears and may even cause injury, whereas it is possible to stand close behind the gun with comparative impunity. In other words, the sound-wave from a gun is more concentrated along its line of fire than elsewhere. No such difference is observable with a shell, its concussion being equally violent to the ear whether it explodes in front of or behind one.

The laws of sound say that the intensity of the sound emitted from a body grows less in proportion to the square of the distance of the ear from the source of the sound; in other words, at double the distance the sound is a quarter as great. This, of course, is identical with the laws of light, and applies perfectly to the shell, but not to the gun, in the same way as the ordinary law of the intensity of light will apply to a candle, but not to a searchlight, which concentrates its light along one path instead of distributing it equally all around. Hence we are driven to the conclusion that the wave of sound emitted by a gun is closely analogous to the wave of light emitted by a searchlight. The intensity of the ray from a searchlight only diminishes gradually, and this analogy is borne out by the peculiar fact, familiar to those who have been in the trenches, that the German machine-guns, or rifle shots, always seem as loud whether the width of "No Man's Land" is seventy yards or 500 yards. One of the most wonderful and, indeed, majestic of all sound phenomena in connection with artillery is the great "roll" that follows the discharge of a high-velocity gun. To hear this at its best one must visit a part of the front where the contour is rugged, or where the landscape is well wooded, and where houses and other excrescences are abundant, as at Arras. The report of the cannon is followed at once and continuously by a majestic echoing roll that may be compared to a mixture of thunder and the music of a mighty bass orchestra. This rolling sound seems to travel forward as though it were following the flight of the shell, and is, indeed, mistaken by some for the actual sound of the shell.

The real explanation, however, is that it is a series of echoes from the thousands of heterogeneous excrescences in the surface of the landscape, each of which sends back its echo to the ear, the whole combining to form a continuous trail of sound. Now the fact that this continuous sound travels in the direction of the shell, and hence in the line of fire of the gun, also fits in with the searchlight analogy; as otherwise if the sound of the firing gun were not concentrated along its line of fire this chain of echoes would not appear to flow in any definite direction, and thus one of the most grandiose aural phenomena that the ear can receive would not exist.

The above considerations give rise to a remarkable and surprising fact, which, indeed, arises in theory and is borne out in practice. This is, that at a certain distance and upwards from the firing-line the sound of the German guns will be greater than the sound of our own, because we are in front of the German guns but behind the British, and although the latter are nearer to us, yet the sound of the former will appear louder and sharper because of the peculiar nature of the sound-wave emitted from the muzzle of a gun, the noise being nearly all concentrated in the direction of fire. Thus, when approaching the firing line before a big attack, the sound of the German guns often appears to preponderate over our own, giving one the apprehensive impression that the enemy's artillery is in superior strength to our own, and it is only in coming into the artillery zone that the British superiority is perceived. Another point illustrating this is the origin of the word "drum-fire." This term (*trommel-feuer*) was first used by the Germans to describe the effect of our massed artillery on an unprecedented scale on the Somme. Now to the British, who were, of course, behind the direction in which their artillery was firing, this term would never have occurred, for to be behind a British bombardment there is but little resemblance to a drummer's tattoo, the whole sound being merged into a dull and heavy roar of guns; but to the German generals behind their lines every shot from the British guns would stand out as a sharp staccato note, the whole combining to give the impression of the rat-a-tattat of a mighty drum tattoo.

From these conclusions it will appear that the further one is behind the firing line the greater is the tendency for the sound of the German guns to preponderate over our own, although the latter may be in much greater strength, and the probability is that the greater part of the noise of firing audible on our coasts comes from the German artillery and not the British, although the sound of shell bursts may tend to modify matters.

Prof. Malladra's Recent Researches at Vesuvius

PROF. ALESSANDRO MALLADRA, the successor of Mercalli at the Royal Vesuvian observatory, has published a number of papers, from 1912 onwards, on the volcanic manifestations and progressive changes in the great crater formed in 1906. It has been possible in recent years to descend, by hazardous paths, to the edge of the central funnel, 250 metres below the crater-edge, and valuable observations have been made on the gases emitted from the fumaroles. Prof. Malladra furnishes a well-illustrated summary of the conditions in 1914 in "Nel cratere del Vesuvio" (*Boll. reale Soc. Geografica*, 1914, p. 753). The gradual widening of the crater by the falling in of its cliffs is shown in detailed plan in a paper, "Sulle modificazioni del Vesuvio dopo il 1906" (*Ibid.*, p. 1237).

The small aperture of 1900 is also here indicated, almost immediately over the pit that is now active. The volcano remained quiet, in a solfataric stage, for seven years after the enormous outburst of 1906; but a glowing funnel opened in the floor of the crater of explosion on July 5, 1913. Prof. Malladra was engaged in a hypsometrical survey on the cone a few hours after this outbreak ("Sui fenomeni consecutivi all' apertura della bocca 5 Luglio, 1913," *Rend. R. Accad. Sci. Fis. e Mat. di Napoli*, fasc. 11 and 12, 1914), and has recorded a true incandescence, accompanied by the emission of fresh scoriae, specimens of which were collected on one of many later visits. The "yellow furmarole" in the crater gave a temperature-reading of 128° C. in 1911. In September, 1913, this had risen to 330°, and in October to 347°.

At the time of the collection of gases from this fumarole for analysis, water condensed, containing hydrochloric acid in the proportion of 9.21 grams per 100 c.c., and smelling strongly of sulphurretted hydrogen. The author points out that, following the arguments of Brun as to the possibility of the permeation of water into a heated mass from without, this water must be truly magnatic. He thus provides further evidence, in addition to that of Day and Shepherd, against Brun's main contention.

Prof. Malladra illustrates ("I Gas vulacnici e la Vegetazione," *Boll. Soc. Sismologica Ital.*, vol. xviii.) the acid gases of Vesuvius rolling in a dense cloud down the mountain slope. They deposit on the leaves and branches of the trees a white dust consisting of chlorides and sulphates of iron and the alkalies; and these anhydrous or slightly hydrated gases are easily recognizable to the experienced eye from the ordinary masses of water vapor.

Like the descending clouds that brought death to Saint-Pierre and Morne Rouge, they consist of very finely divided solid matter and gas, and resemble the smoke of a conflagration. The caustic effect produces brown spots and decay in leaves, and experiments are in progress in the planting of bare parts of the Vesuvian slopes with Euonymus and with a bamboo, appropriately known as *Arundo Plinii*, which flourishes fairly upon Stromboli. Both these, it is hoped, will resist the acid emanations.

An investigation of the rainfall on Vesuvius, and of the distribution of snow on the variously heated areas near the vent ("La pioggia sul Vesuvio, 1863-1913," *Ibid.*, vol. xviii.), contains an interesting passage on the snow-accumulations formed by the freezing of the vapor of the fumaroles.—*Nature*.

Between the Tigris and the Indus*

A Region of Great Future Commercial Importance

By Colonel Sir Thomas H. Holdich, Former Surveyor General of India

On the British Indian frontier, some two hundred miles to the west of Peshawur, there is an upland of open rolling plains, intersected and encompassed by rugged mountains, well watered and fertile, enjoying, on the whole, a temperate climate, bright and warm with sunshine in summer and wrapt in the snowy mantle of an Eastern Switzerland in winter. It is, indeed, a Land of Promise. The wide plains are spread with a shimmering sea of upspringing corn, and at the far edges of the plains the lower slopes of the mountains are half veiled in a light-blue haze which faintly reveals white villages clinging to their craggy spurs. Near by, the running streams of bronze irrigation water, bordered by groves of mulberry and scented willow, are often pink with the scattered petals of peach and almond blossom. It is a land of the vine and the olive and the melon, and of a great wealth of later autumn fruits. In winter it is icebound, with much display of the fantastic beauty of ice shapes in waterfall and river fashioned by the frost grip under the shadow of the snow-capped hills which stand round about its outspread capital; but the winter is the winter of Switzerland.

Apart from its academic interest, it is a subject of vital importance to us at the present time to know what lies between the Tigris and the Indian frontier, for events are gradually shaping themselves there which may ultimately affect our own destinies profoundly. We know that for centuries, since the Turk and the Mongol blocked the way to overland commerce between the Far East and the West, commerce has been forced, so to speak, into the sea. There was a time when, across the width of Persia, by at least two world-old highroads, the slow caravans passed and repassed, wearing deep ruts where the camels trod, bringing silks and spices and merchandise from Central Asia and India to Syria and the West. Then came the sweeping hordes of the northeast to interpose a barbaric wedge, which practically shut the main gates of the Eastern trade. European ships then began to find their way to India and China, and one by one rival competitors for the seaborne trade sprang into existence.

Now, once again, does there appear to be in a not very remote future the chance of a revival of that old world-honored overland trade which existed before the days of Israel, which brought the treasures of the East to the marts of the West. There is abundant evidence before us that this desire of the nations—the acquisition of the highway to the East—is again a powerful force in international politics. Two notable events have lately been recorded in the progress of Eastern affairs which bear directly on this important question of overland communications—they are signs of the times and portents of the future. The first railway has been opened in Persia. For the first time has the blue-coated agriculturist of northern Persia stared open-mouthed at a locomotive, bearing a huge national emblem, traversing his fields. This is the Russian military line which connects Batum on the Black Sea with Tabriz. The other event is the piercing of the Taurus tunnel by the Germans, which will rapidly bring Constantinople and Bagdad into direct communication by rail and place a rival enterprise on the Mesopotamian field.

As we are now dealing with a region where geographical disposition of mountain and plain has shaped the destinies of nations from the very earliest dawn of history, and as the same geographical factors will yet again shape the course of a history as yet unwritten, it may be interesting to refer briefly to their chief characteristics.

The great plateau of Persia, overlooking Mesopotamia across rugged bands of Kurdish mountains on the west, is shut off from the steppes and highlands of the north by a continuous series of mountain systems, which stretch from Armenia to Afghanistan and beyond through the heart of Asia. But this mountain rim is for a great part of it narrow and easily passable, bordered on the Persian side by a continuous edge of grassland, through which runs the much traversed road connecting Teheran with Meshed and Afghanistan. There are important commercial towns along this route, but the value of it is largely discounted by the fact that the nomads of the steppes north of the mountains still carry their raiding enterprises (*alamans*) over the hills and into this grassland. South of the strip of cultivable country lie the great central salt deserts, separating it from the next important route, traversing Persia from west to east, which starts from Bagdad, follows the old Median Way to Kermanshah, and then passes by Kirman to the Indian frontier. These are the two great important highways between Mesopotamia and India which are bound, both of them, to become something more than mere geographical features in a not very remote future. To the north of that mountain barrier, and extending eastward and northward farther than we can tell, in the early dawn of history there dwelt scattered clans of a vast Asiatic horde—Scythians and Sarmatians, of whom we have but a shadowy record. We know, however, that about the period of the Israelite captivity they were crossing the Don, already pushing their way westward towards Europe.

The geographical position of Nineveh also demands a short examination. South and east of Nineveh, hedging in the plains of Mesopotamia, are bands of wild mountain ranges, rank upon rank, forming a revetment to the Persian plateau, which are extended parallel to and facing the Persian Gulf and Arabian Sea to the Indus basin. They are full of uncouth and unconquered highlanders of many clans and various derivation, some of whom retain the names given them in the records of Herodotus, who wrote five centuries before our era and about two and a half centuries after the fall of Samaria. Immediately north of Nineveh, where rise the sources of the Tigris and the Euphrates, are the mountains of Armenia, reaching to the southern shores of the Black Sea. Through these hills eastward and northward lie those difficult routes, once open to Greece and Assyria, which now, in the process of historical evolution, are again open to military movement. The road from the north, dominated by Bitlis, and the road from the east, dominated by Kermanshah, which have both been in Russian hands, converge on Nineveh—or rather on Mosul, which is the modern representative of that ancient capital, and which is the chief center of Turkish military activity in Mesopotamia. Thus once again does Nineveh assert the importance of her geographical site as one of the gates to Mesopotamia.

To turn now to this high rolling land of which I spoke in the beginning. This is the home of the Ben-i-Israel (i. e., sons of Israel). The capital town, crescent-shaped and hill-protected, is Kabul; and the country about it is the upper Kabul River basin, a part (and perhaps the most important part) of Afghanistan. The name Afghanistan arouses many memories in many of us; one unfailing point of interest in connection with it is its origin. Afghanistan means, of course, no more than the home of the Afghan; but who is the Afghan, and where does he come from? The name has become crystallized now in Indian history and Indian frontier records for nearly two centuries, but it is apparently only as old as the days of the founder of the Durani dynasty, Ahmad Shah, and it is not a name, so far as I know, acknowledged by any one of the extraordinarily mixed nationalities that occupy Afghanistan. There are Turks and Tajiks, Arabs, Persians and Mongols, with Pathans of mixed origin and all of very ancient lineage, and there are the Ben-i-Israel—but no specific Afghan. I know no one from the mountains of Kafiristan to the deserts of Baluchistan who calls himself Afghan. It is, however, just as well that we should have a recognized British official term for all the peoples governed from the Kabul center of administration within the boundaries fixed to the Amir's dominions, and the name Afghan is far too useful to quarrel with.

The Ben-i-Israel belong to (if they do not comprise) those Durani clans who established themselves as the dominant power in Afghanistan after the death of the great Persian ruler and robber, Nadir Shah, in the eighteenth century, and, consequently, the Amir of Afghanistan is their ruler and chief. They spread over a great part of the upper basin of the Kabul River, and are to be found on both sides of the Hindu-Kush as well as in the basin of the Swat River, where they are known as Yusufzais. In the absence of anything approaching to reliable statistics I will not venture to give an estimate of their numbers, but, at a rough guess, I should put them at about one-fourth or one-fifth of the entire population of all that we call Afghanistan.

Certain ethnological and philological facts point to their Israelitic origin. The statement that the captive Israelites were transported from Syria to regions beyond the Euphrates is vague. Nineveh itself is beyond the Euphrates; together with all the valleys of the upper Tigris and Armenia and Lake Van, Erzerum and Bitlis are all beyond the Euphrates so far as Syria is concerned—but Armenia is the country for which there is historical authority for locating them. This, however, is comparatively unimportant if we consider the statement of Josephus that seven centuries and a half later they were still a "great multitude" gathered beyond the Euphrates. So that it is only within the last eighteen centuries that they have become so scattered and absorbed by other tribes and races as to leave no trace of national existence. But doubtless the true Semitic spirit of the nomad possessed them and, like the Jews, they probably spread in small groups right through Asia. There is every reason to suppose that they did so. Unlike the Jews, they sacrificed their national cohesion to the lost faith of their forefathers, which had weakened long before they left Samaria. The rites and ceremonies of Jewish ritual, which are still so powerful a factor in maintaining the national unity of the Jews, had given place to strange forms of worship with a general tendency towards idolatry, nor was that federation of tribes which formed the Kingdom of Israel free from constant internal strife and disturbance. Thus elements of disintegration were deeply rooted among them.

There appears to be some confusion of thought as to the identity of the Captive Tribes. According to Kitchener (who was a surveyor in Palestine long before he became a war lord) it is impossible to define the former limits of individual tribes, but there is evidence to show that these limits had disappeared altogether in certain cases before the Captivity. For instance, the tribe of Simeon appears to have retained the nomadic instincts of the race and to have become assimilated with cognate tribes such as the adjacent Edomites and Moabites, only retaining certain holdings within the regions occupied by Judah. Simeon, you will remember, occupied the southern extremity of Palestine, south of Jerusalem, and reached down to Bir-es-Saba (or Beersheba), which is now the base for Turkish military activity in the direction of Egypt. The Captive Tribes were, however, described as an "immense multitude" in the first century of our era by Josephus, and they were still "beyond the Euphrates." But as Josephus is the authority for the statement that a million Jews were destroyed with the fall of Jerusalem, and as this is an impossible number, we may perhaps discount the great multitude of the Israelites. There is nothing whatever to show that at this time (about the year A. D. 70, nearly eight hundred years after their captivity) they were anywhere but in the position assigned to them by the early chronicles—i. e., beyond the Euphrates. Still less can we discover evidence that they had migrated in a body to steppe regions beyond the Black Sea and had become incorporated with the Scythian tribes who had then spread into Europe.

A few words about these Scythian nomads may be interesting in view of certain fantastic theories (thoughtlessly accepted by thousands) that they absorbed the Israelites, or that, in some inexplicable manner, the Israelities became Scythians. When the Greeks began to colonize on the north coasts of the Black Sea, about the time that Samaria fell, they encountered these steppe nomads as they gradually extended trade eastwards by a route into Central Asia which crossed the steppes from the Don to the Ural (about Orenburg), and thence carried traffic southwestward to regions between the Jaxartes and the Oxus beyond Lake Aral. From the Don to the Ural the route mainly traversed the country of a kindred people called Sarmatians, but on the Oxus and between the rivers Scythians again prevailed. Thus they were to be found at intervals in regions extending from the Oxus to the Black Sea, and, indeed, it seems probable that they were still farther west. They appear to have been first mentioned by Hesiod about 800 B. C., and, by the time of the Captivity, 721 B. C., a good deal was known about them, as appears from the writings of Herodotus. They seem to have occupied all Wallachia, and the Dniester was Scythian as far as the Greeks knew it. They were an immense and widespread people, and with them certain European peoples trace an ethnographic connection, based (with some probability) on the similarity of the name Sakai with Saxon, and the known direction and

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extent of the Scythian irruption into Europe. The Scythian hordes invaded Medea and overran Western Asia about one hundred years after the Captivity, and, after extending their raids into Palestine, they finally destroyed Nineveh. Then, if ever, the Scythians and the Israelites met. But we know that the Scythians retired northward again and that the Israelites were still an immense multitude beyond the Euphrates many centuries after the tragedy of Nineveh's fall. There was no absorption then, and it is inconceivable that it should have occurred after the days of Josephus and the destruction of Jerusalem.

It is, indeed, almost inconceivable that any considerable tribal emigration left the valleys of plenty and of great natural beauty which lie beyond the Euphrates in the uplands of ancient Medea and Armenia to search for a home in the South Russian steppes. The assimilation or absorption of the Israelites by the Scythian tribes may surely be regarded as an ethnographical impossibility. We are confronted with many problems of international assimilation when we deal with national frontiers, but an absorption of one people of strong individuality by another of totally different physical attributes, leaving no trace behind, is practically unknown. I am reminded of the story told about Sydney Smith, who when he was reminded that there will come a time when the lion will lie down with the lamb, replied: "Yes, but with the lamb inside the lion." That, indeed, is descriptive of a process of assimilation which leaves no trace; but no vigorous and virile people have ever been swallowed up in this way. The incomprehensible but immutable laws of heredity prevent it. The impress of physical feature and of character inevitably recurs, sometimes continuously, sometimes after long intervals; but the result is certain, and, indeed, that result is often comparatively independent of numbers and based far more on character. No trace whatever of Semitic (still less of Hebraic) admixture seems to be recognizable among the Saxons of Germany, whose claim to Scythian extraction is difficult to overlook. This is what Hippocrates says of the Scythians or Sakai, of his time: "They have stout, fleshy, flabby bodies, the joints concealed by fat, their countenances somewhat ruddy. They all looked alike. They lived on boiled flesh, mare's milk and cheese; they never washed, but enjoyed a narcotic intoxication in combination with a vapor bath. . . . The women daub themselves with paste, which they remove every second day." There is a certain irresistible suggestion of the stout beer-drinking Saxon of modern Germany in this unflattering portrait of a great people, a suggestion which imposes the conviction that Saxon and Scythian are of one original race.

After this more or less academic discussion, we turn again to the historical and geographical conditions, human and physical, of that old time-worn and well-trodden region between the Tigris and the Indus which has seen great empires and dynasties rise and fall and which is now relegated to a position among the nations which admits of no pride of race, no military importance—nothing but economic poverty and administrative incapacity. The rights of the highways through Persia, if not Persia herself, have become the desire of Western nations, and we hear loudly expressed political aspirations for the open "road to the East." What does the East mean? Does it mean Persia and Central Asia, or does it mean Afghanistan, India, and China—or all of them? I think we may take it that it undoubtedly means India directly and the rest ultimately. I have already drawn your attention to the fact that the iron rails of two great systems emerging from Europe now point eastwards, and that neither of the two belongs to England. One is Russian from the Black Sea, the other is German from Berlin and Constantinople.

Let us look at Russia's opportunities first. From Julfa, on the Aras, where the boundary between Russia and Persia is crossed, to Tabriz is only 93 miles; Tabriz being, perhaps, the most important commercial center in Persia, with a great trade in carpets, cotton, dried fruits, etc. Moreover, Tabriz is, or will shortly be, in direct connection with the great agricultural districts round Lake Urumia to the west, and by its connection with Tiflis it becomes an important branch of the whole great Russian railway system. We may be well assured that this important innovation into Persian territory was not undertaken for the sake of bringing carpets and raisins to the Russian market. We may indicate Teheran as the immediate military objective where railway extension will support the long-considered scheme of Russian domination throughout Northern Persia. To Teheran there is about 350 miles of somewhat narrow mountain approach under the shadow of the Elburz ranges; but it is a well-known route, carrying a telegraph line, which encounters no greater obstacle than one comparatively low watershed (I do not know the exact height of it) and a bridge over the Sefid Rud, before reaching the important town of Kasbin, about 100 miles short of Teheran.

From Teheran there opens out at once a magnificent prospect eastward—perhaps the greatest that the Eastern world affords. The military domination of all northern Persia would be incomplete without the support of a railway skirting on its southern side the great mountain system which reaches from south of the Caspian to the western borders of Afghanistan. We may take it for granted that the necessary line will follow. If it follows the old trade highway to Shahrud, Bujnurd and Kuchan to Meshed, it will not only tap, and at the same time develop, the resources of a most fruitful district of Persia, but it will set an end to the raiding proclivities of the Turcoman horsemen who still, from time to time, harry the open grasslands south of the mountains. From Meshed (about 550 miles from Teheran) will follow an inevitable 100 miles of mountain line to a junction with the Trans-Caspian system in the north, and the almost equally certain extension to the extreme Russian frontier post near Kushk, 80 miles north of Herat. Whether it will eventually reach the Oxus plains about Balkh and join up with that further branch of the Trans-Caspian system which is expected to link Bokhara with Termez on the Oxus (just north of Balkh) is at present unknown, but there is nothing to prevent it except the susceptibilities of Afghanistan, and in the fulness of time it may be looked upon as an almost certain issue. Equally certain in the long future (perhaps not so very long) is the connection with India. The connection via Herat, easy as it is, has often been discussed and as often dismissed from the category of immediate possibilities on account of the interposition of Afghan territory and the direct opposition of the Amir to railway extensions in his country. It is, however, not necessary that we should trouble the Ben-i-Israel in this matter, for there is no insuperable obstacle to a connection via Birjand and Seistan, to the west of the Helmand River, a connection which would open out local commercial prospects which might eventually go far towards justifying the expense of maintenance. The other obvious opportunity to Russian enterprise is a line from Teheran southward to Kashan and Ispahan, and thence through the great commercial centers of Yezd and Kirman to Baluchistan and India. Such a line as this would be the making of Persia. Whoever builds this line holds Persia in his hands and must exercise paramount influence on her destinies. It is Persia herself who should construct such a line as this and secure for her revenues the enormous advantage of a great through mail service between Europe and the East.

Just what I have so lightly and so inadequately sketched may indicate Russia's position in the contest for the highways to the East. Germany's position is perhaps not quite so clear. Absolute dominance in the Balkan States and in Turkey is the basis of it all, and the open line to Bagdad is the inevitable sequel which appears at present to be well within her grasp. But what beyond Bagdad? It is, I think, sufficiently clear that she might have visions of a line passing up the old Median Way to Kermanshah, and thence extending itself along that upland road which I have already pointed out as passing by Yezd to Baluchistan. But I very much doubt if any such ambitious program was ever regarded as a probable, or even possible, result of a Bagdad occupation. She might, again, look to lower Mesopotamia and an extension to Basra, thus securing for herself not merely the upper half but the whole wealth of the rich Mesopotamian plains when Sir William Willcock's great irrigation scheme ripens into an accomplished fact. That, indeed, would eventually amply repay the outlay on the whole project. It would be a magnificent contribution to the Eastern world's development, and it would bring Germany to a seaport at Basra. That, again, does not seem (so far as any indications as yet presented to the public are trustworthy) to be her present ambition. The line to Bagdad in itself would sufficiently tap the broad wheat and cotton areas, and would go far to drain our Basra trade dry without any excursion southward. Moreover, when Germany makes a bid for Eastern commerce you may take it that her ambitions are wholesale and far-reaching. It is not merely Mesopotamia and Persia, or even India added, that fills her horizon. You must also add China, and remember the millions that she has already sunk in securing a footing in that Celestial republic (if it is a republic). That is perhaps why, in days before the war, it was not Basra that figured in German propositions, but the port of Koweit, south of Basra, commanding the seaway to Basra, and untrammeled by a long shallow-river approach with a bar and bottom of mud. That is perhaps why in these days, when any faint suggestion is made of the peace terms that would suit Germany, we always hear that England is to give up control of the sea. What does it mean? The North Sea and the Atlantic have ever been open to German shipping. Her ships have been able to come and go as they please. But she has not been able to plant coaling and, incidentally, submarine stations on any coast she pleased, nor has she obtained a port in Eastern waters between Suez and China. Here, I believe, we have the true explanation of German ambitions as regards Eastern trade—ambitions which would involve a direct threat to Indian traffic if not to India herself (for we must remember that India is far more vulnerable by sea than she is by land). This consummation of her hopes is for us to deal with—not for Russia—and the consideration of it brings us back to a fuller appreciation of the meaning of political domination in the Balkans and Constantinople, and, finally, of that command of the sea which is far more to us than any conquests or expansions by land that we are ever likely to contemplate.

We have, however, rather drifted away from the Tigris and the Indus whilst following out this brief consideration of the "road to the East," the command of Eastern trade, which has become the dominant factor in the war. In conclusion, I would suggest that, apart from these war questions, which are necessarily of vital and immediate interest to us, there is ample and most interesting opportunity for inquiry and research into the academic fields of the history and ethnology in the regions which lie between the Tigris and the Indus. There is, I hope, a prospect that opportunity for such investigation is not far distant. We want to know more than we know at present of the Armenians and their records as well as of the Ben-i-Israel; and we want a closer geographical knowledge of all that lies between Herat and Kabul. Above all do we want a scientific examination of the site of the city of Kalkh, which would surely yield results of importance and historical interest such as would rival even those of Nineveh.

Determination of the Density of Solids

THE authors point out the very considerable divergence between the values of the density of solids given in the literature. They consider that the most important source of error in the determinations is the adhesion of a thin layer of air to the surface of the immersed solid. On carrying out a number of determinations of the density of a few solids immersed in different liquids, they find that when water is employed the errors in the determinations are very considerable, but when benzene, mineral spirit, or carbon tetrachloride is employed, the values are concordant to within 0.06 per cent. Water, therefore, should never be used for the immersion of solids in determinations of the density.—H. LE CHATLIER and F. BOGITCH in *Comptes Rendus*.

The Efficiency of the Employe

As commercial competition increases, with every prospect that it will become still more intense, the employer is giving more attention to making his employes more efficient. In years gone by it was a matter of indifference to the employerhow of ten the personnel of his factory changed: Now he begins to realize that a workman earning $1,000 a year represents an investment of $20,000 at 5 per cent, and that the time required to teach this man to do his work properly means so much loss of profit. Under the new system the employer seeks to reduce changes in his force, and not only to hold efficient men, but to remove every interruption or annoying environment that will affect the contentment of mind of the employe; especially if the element of personal prejudice being eliminated.

Destruction of Field Mice

M. STRANAK gives an account of his experiments in the destruction of field mice, with especial reference to their ravages in clover fields in Bohemia. In the spring of 1915, which being a dry period was favorable to their propagation, he counted as many as 10 holes per square yard and the plants were quite destroyed for 6 inches around each hole. It is first required to find out whether the holes are inhabited, and they are then closed by trampling upon them, and 3 or 4 days later the opened holes are treated with various substances. A good method is to introduce a handfull of grass covered with phosphorus paste or arsenical compound. Morphine pills are good only in dry weather. Fumigation by sulfurous gas from burning sulfur is to be recommended, and liquid sulphurous acid can also be used with success. Phosphide of zinc is sometimes employed.

Building a Moving-Picture Camera

A Serviceable Home-Made Machine for $6.50

By E. H. Williamson, Jr.

THE interest in moving pictures is practically universal, and it is probable that there is not a village of any size in the United States which does not have its moving picture palace and a corresponding group of "fans." No doubt many of the readers of the SCIENTIFIC AMERICAN have wished that they owned a camera, while witnessing some thriller such as "The Illusions of Ida" or "The Pranks of Patricia," but when they came to get prices on such cameras, they decided that it would not be worth the expenditure. However, a camera suitable for the use of an amateur can be built for the sum mentioned in the title, even with the inflated price of all materials, if the reader possesses some mechanical ability and handiness with tools. Of course, an outfit at that price necessitates a very inexpensive lens and any departure from the text in this direction will of course increase the price accordingly. To those who do not understand the mechanism of a moving picture camera, the following short explanation will be in order. Moving picture film is like any other film except that it is sold in lengths of many feet and is perforated at the edges. The standard film is 1⅜ inches wide, and the perforations are ⅜ inch from center to center, making four to the picture, the latter being ¾ inch high by 1 inch wide. This film is wound on a reel either inside or outside the camera and runs down through a framework which holds it in the focal plane of a short focus lens, usually three inches or less, in focal length. In taking the pictures, the film is mechanically wound through this frame to an empty reel located below or beside the other, but the movement is intermittent and at the rate of 16 per second, this having been found the proper speed to avoid flickering when the picture is thrown on the screen. This movement is obtained by the use of a pair of claws which engage in the perforations, and are geared to a train of wheels turned by the crank of the camera. A revolving shutter connected to these wheels makes an exposure at each period of rest between the movements of the claws which draw down the film.

The camera to be described is shown clearly in Fig. 1 which gives a view of the interior from the right hand side; and Fig. 2 which shows a perspective of the other side. The box (A) is made from straight grained poplar free from knots, finished on both sides, the top and bottom pieces being ¾ inch thick and the back, front, sides and partition being of ¼ inch stuff. The outside dimensions of the box are 10 inches long, 10 inches high and 8 inches wide, not counting the ¼ inch thickness of the sides. It is fastened together with screws to allow of being taken apart if desired. The blocks (B) and (C) which support the train of wheels and the reel spindles, may be made of one piece of wood or built up of 1 inch board, (B) being 5 inches long, 2 inches high and 2 inches thick, (C) is 5 inches long, 2½ inches wide and 2 inches thick. (C) rests on top of (B) and is fastened to it with an angle iron and the combination is set 1 inch inside the edge of the box and screwed to the back and baseboard.

The large gear wheels (D), (D′) are 2 inches diameter, 32 pitch, ⅛ inch face, and a ⅛ inch hole. The spindle of (D) is of ⅛ inch round, mild steel bar 5 inches long, the gear being set in the center. The inner end of the spindle is threaded for ⅜ inch and the outer end is threaded for 1 inch.

The spindle of (D′) is 3 inches long and threaded for

The camera as it appears in operation

⅜ inch at the inner end, and the gear (D′) is driven on for half an inch at the other end, and next to it is driven the ½ inch gear (E) of the same pitch and thickness as (D′), the hole in (E) being reamed out to make a driving fit. In case any of the gears do not make a tight fit on the spindles the surface of the latter should be nicked lightly with a cold chisel. The gear (E′) is the same size as (E) and is driven for ½ inch on a ⅛ inch spindle 3 inches long, the inner end of this being threaded as in the other cases. On the projecting end of this spindle is driven one of a pair of ½ inch brass miter gears (F), (F′), having ⅛ inch holes. The gear (F′) is driven on the end of 4-inch spindle, ⅛ inch diameter supported in bearings on the block (G) which is 2 inches high, 3 inches long and ⅝ inch thick. It is screwed firmly to the base, and the bearings (H), (H′) which are of brass strip ⅛ inch thick by ½ inch wide and 1½ inches long are screwed to the sides of (G) in such a position as to allow the gears (F), (F′) to mesh easily and the spindle to revolve freely in the bearings. The outer end of the spindle projects through the partition and terminates in a 12-tooth brass sprocket wheel (b′) the use of which will be taken up later. The train of gears is supported in the brass strips (H^2), (H^3), which are ½ inch wide by ⅛ inch thick, and 5 inches long, and are screwed to each side of the block (B), ½ inch below the top, holes, ⅛ inch in diameter being drilled through the wood to allow free passage to the spindles. The block (C) is provided with similar bearing strips (H^4), (H^5) which support the spindles of the reels (K) (K′). The lower spindle is ⅛ inch diameter and 5½ inches long and on the end is driven a gear (J) ¾ inch diameter of the same pitch as the gear (D) with which it meshes. The inner end of this spindle is threaded for ½ inch as are both ends of the upper spindle (I), which is of ⅛ inch mild steel, 5½ inches long. The reels (K) (K′) are made of wood, the barrels being turned to 1½ inches diameter by 1½ inches long and the flanges are made of cigar box wood, 3 inches diameter. Two pulleys (L) (L′), shown in Fig. 3, ⅛ inch thick and 1½ inches diameter with conical grooves, are turned from poplar and nailed to the flanges of the reels as shown. At the centers of the other flanges are screwed 1-inch disks (M) (M′) of ⅛ inch brass drilled in the center to receive the spindles. To the lower disk is soldered a brass nut, threaded to fit the spindle, and this can be screwed firmly to the latter so that the reel will turn when the spindle does. The nut of the upper reel is not soldered to the disk, as the reel turns freely on the spindle. If the spindles have been tapped to an ⅛ thread these nuts may be taken from disused dry batteries. The claw movement which pulls the film is shown clearly in Fig. 2. To the inner end of the spindle of gear (E^1) is screwed the crank (N), which is a strip of brass ⅛ inch thick, ½ inch wide and 1 inch long. Two holes are drilled in this, ½ inch apart from center to center, and tapped with an ⅛ thread. Into one of these the end of the spindle is screwed and into the other, the crank pin (O) which supports the claws. It is of ⅛ inch mild steel, 2 inches long, threaded for ⅛ inch where it screws into the crank and for ⅜ inch at the other end. The shape of the claws (P), (P′) is shown in Fig. 2. They are 1½ inches long, ⅜ inch wide at the widest part, and the points are ½ inch long. They are drilled out to turn easily on the crank pin and are connected a little above the center by a cross-

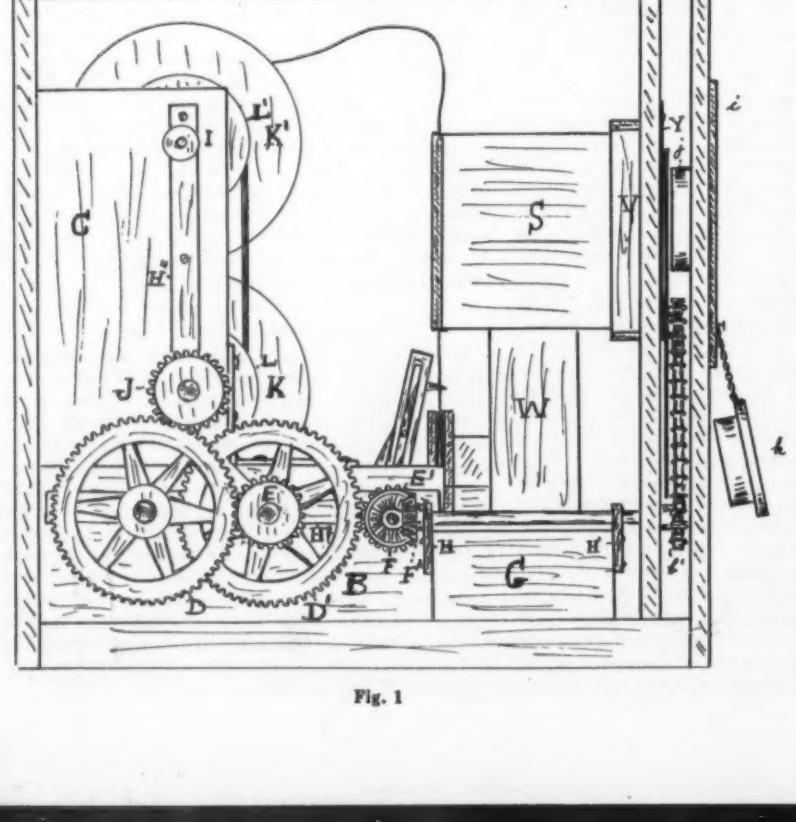

Fig. 1

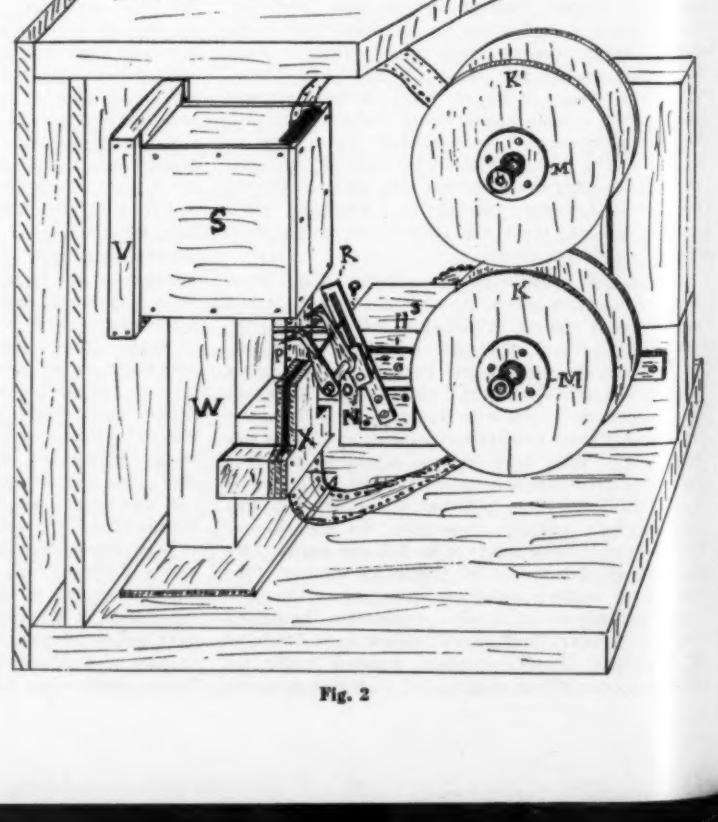

Fig. 2

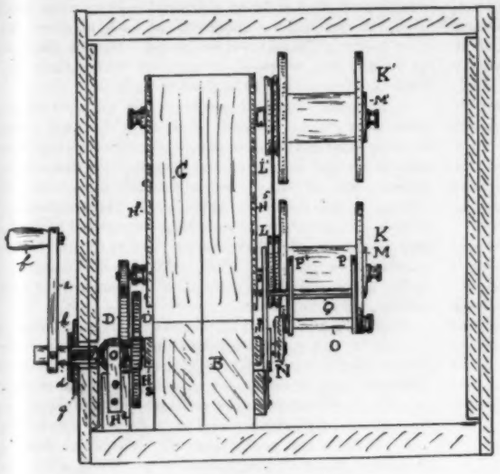

Fig. 3

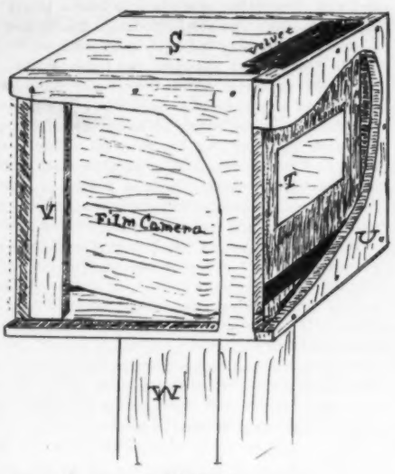

Fig. 4

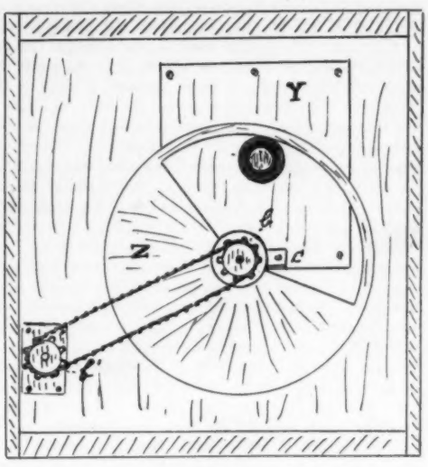

Fig. 5

bar (Q) of ⅛ inch brass rod, 2 inches long, which is soldered to both claws. It engages in the slotted guide strip (R), of brass strip which is 4 inches long, the slot being 2½ inches long and a shade over ⅛ wide. This is screwed to the side of the block (B) at an angle of 20 degrees with the perpendicular, and gives the claws an eccentric motion, and enables them to enter the perforations of the film, draw it down for ¾ inch and then withdraw themselves and repeat the motion.

Figure 4 shows a large view of the box which contains the lens and the guide or gate as it is called through which the film travels.

It is made of cigar box wood and the inside dimensions are 1⅝ inches wide, by 2¼ inches high, and 2⅛ inches deep. This will receive the inner mechanism of one of the little box film cameras, the smallest made. This camera has a meniscus lens of 2½ inch focus, which is stopped down to f. 16, but as the picture to be covered is little over two-thirds of that regularly covered by the lens, this stop may be increased to f. 8 without marked loss of marginal sharpness. In Fig. 4, the case is shown, cut away to show the position of the film camera and the arrangement at the back. The slot at the top and bottom of the box is 1½ inches long by ⅜ inch wide. A strip of heavy black paper (T) is glued and tacked across the back of the box at the inner side of the slot so that the rear of the little camera lies against it, and in the center is cut a window 1 inch by ¾ inch through which the film is exposed. The inner face of the back board (U) is lined with a strip of black velvet 1½ inches wide, to prevent scratching the film, and the other edges of the slot are likewise protected.

Where the case rests against the partition it is surrounded by a light frame of cigar box, (V) which makes a light tight joint. The case (S) is supported on the pillar (W) which is 4 inches high, 1¾ inches wide by 1½ inches thick, and is nailed to a base board of cigar box wood as this makes it easier to shift it around and be certain that the film slit is directly in line with the claws (P), (P'). The film guide (X), is composed of two T-shaped pieces of cigar box wood 2 inches wide at the bottom, 1 inch wide at the top and 1¾ inches high, They are separated by narrow strips of wood so as to leave a $\frac{1}{16}$ inch slit between them, 1½ inches wide, the inner faces being lined with black velvet as with the case (S). It is set on a block nailed to the side of the pillar (W) at such a height as to clear the lower ends of the claws in their revolutions, and must of course, be directly under the slot in the case, so that the film enters it vertically. We now turn to Fig. 5 which shows the shutter and the chain gear which drives it. A 1-inch round hole is bored in the partition, opposite the center of the camera case (S), and over this is tacked a square of black cardboard (Y), 3 inches by 4 inches with a ¾ inch hole in the center. The shutter (Z) is 5 inches in diameter and cut from a thin piece of the black japanned iron called "Ferrotype" which is sold by photographic supply houses. A window is cut in this a little less than half the area of the circle, leaving a narrow rim of metal all around to stiffen it. To the center of the circle is rivetted or screwed a 1½ inch brass disk (b), $\frac{1}{16}$ inch thick and to this is soldered, centrally, the hub of a brass sprocket wheel, the same size as the wheel (b') on the end of the miter gear spindle. The shutter and sprocket revolve on a steel pin which is screwed firmly into the strip (c), which is screwed to the partition.

The two sprockets are connected by brass ladder chain so that the miter gear shaft and the shutter revolve simultaneously. It is very important to adjust the revolution of the shutter so that the lens opening is covered by the latter at the beginning and during the whole period that the claws are pulling down the film, and opened during the entire period of rest. This will require some experimenting but when once found will be permanent. The sides of the camera are of ¼ inch poplar, the left hand side, facing the camera being attached with screws so that it can be easily removed to give access to the machinery. The other side is attached with hinges so as to allow the removal of the reels. On the inside of both side pieces are nailed two rebates as shown in Fig. 6 one fitting into the main body of the camera and the other into the space between the partition and the front board of the camera. The crank by which the mechanism is driven is shown in Fig. 3 and also in detail in Fig. 7. A sleeve (d) of brass tube, 1½ inches long and ¼ inch inside diameter is threaded to fit the projecting end of the spindle of (D).

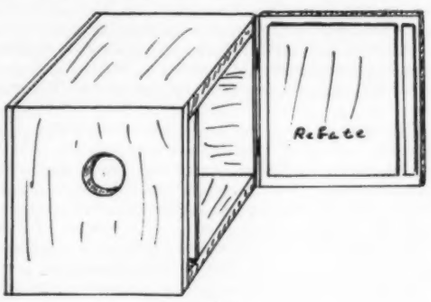

Fig. 6

The crank (e) is cut from ¼ inch brass and filed to the shape shown in the figure. It is 4 inches long and is fitted with a turned wooden handle (f) fitting loosely on a 2-inch stove bolt screwed into (e). The sleeve (d) runs through a bearing disk (g) screwed to the side of the camera, and the hole in (g) is just enough bigger than the sleeve to allow it to turn freely. To further shut out light, a brass flange (h) which is 1 inch diameter, $\frac{1}{16}$ inch thick is soldered to the sleeve close to the disk (g).

In the front board of the camera, opposite the lens opening, is cut a 1½-inch hole, and over this is tacked a 3-inch by 4-inch piece of cigar box wood (i) in which a trifle larger hole has been cut, and in this hole is fitted a 1-inch length of cardboard tube (j) which projects inward towards the shutter, and shuts out extraneous light. This tube is closed when the camera is not in use, by the plug (k) which is attached by a chain to the front board. The arrangement is shown clearly in Fig. 1.

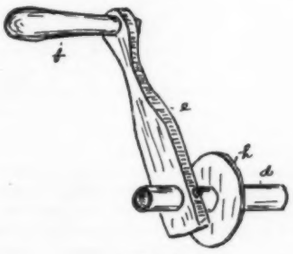

Fig. 7

The entire interior of the camera must be painted a dull black, using a matte varnish and the brass work must be likewise blackened either by pickling or with black lacquer, in which case the lacquer must not be allowed to get in the teeth of the gears or clog the bearings. If it is not convenient to blacken the metal parts, they may be shut off from the film by a carbdoard partition made of heavy photo-mount and tacked to the sides of the wooden blocks (B) and (C). In this case, holes must of course be cut for the various spindles. The camera may be given a coat of lustrous black varnish outside or covered with leather cloth, the latter being preferable.

The sides and front board should be covered separately and attached with screws with the heads outside the cloth. As a view finder is necessary it may consist of a direct vision finder attached to the upper front edge of the camera as shown in the photograph, or may be simply a rectangular wire frame, fitted with cross wires, through which the view may be centered and limited. In either case it should be directly over the lens. On the case of the little camera will be found lines which show the view included by the lens, and these may be transferred to the big camera as guides. The reels of the camera will contain about fifty feet of negative film which is thinner than that used for projection. It is a good scheme to obtain a few feet of discarded film from a supply house and use it in adjusting and testing the mechanism, and it is also a good idea to use a piece of this film at each end of the negative film, cementing the ends with quick drying film cement, as this allows the old film to be fed through the machine when starting the latter, without using up

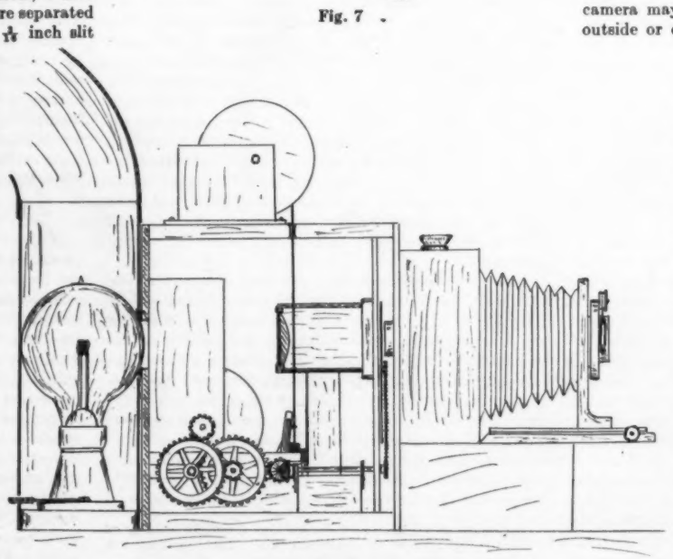

Fig. 8

good film. To load the camera, the upper reel is removed and wound full of film, the inner end being secured with a tack. The end is then slipped through the film gate in the box (S) down past the claws to the guide and so to the lower reel. A short amount of slack is left where the film leaves and enters the reels to allow of free running and after this is done the belt of rubber band is slipped over the pulleys. This work must of course be done in a safe red light and having been completed, the camera door is closed and latched, and the plug inserted in the lens tube. The camera may now be taken out in daylight and put to use. As it is very necessary that the camera be used on a firm support, unless the reader has a large view camera tripod, it is better to make a tripod specially for this use by procuring three wooden strips 1 inch by 1½ inches and 5 feet long, and fastening the ends of these to the bottom of the camera with strong iron hinges. The hinges are placed so as to form a triangle and the lower ends of the sticks are provided with sharpened nails to avoid slipping. As the camera lens described is not a rapid one all pictures should be taken in bright sunlight and very rapidly moving objects would be avoided. The crank should be turned at the rate of two turns per second which will give 16 pictures per second.

The cost of materials is shown in the schedule below but may vary some in different parts of the country.

Wood	
¼ inch poplar 5 feet long 10 inches wide, finished both sides ¾ inch poplar 2 feet long 10 inches wide, finished both sides 1 inch by 3 inches poplar 2 feet long, finished both sides	$1.00
Gears	
2 spur gears, 2 inches diameter, ⅜ face, ⅜ in hole	.84
2 spur gears, ½ inch diameter ⅜ face, ⅜ in hole	.24
1 spur gear, ¾ inch diameter, ⅜ face, ⅜ in hole	.18
2 ½-inch miter gears, ⅜ face, ½ in hole	.60
2 10 tooth brass sprocket wheels, ½ in hole	.48
1 foot of ladder chain brass for above	.10
1 foot each of ¼, ⅜ and ⅜ inch mild steel for spindles	.30
2 feet brass strip ½ inch wide, ½ inch thick	.30
Brass tube, sheet, bar chain, etc	.40
Small Film Camera	.75
1 square yard of Buffalo grain leather cloth	.50
Varnish, black velvet, glue, nails, screws, etc	.60
Total	$6.29

The film for moving picture cameras costs four cents a foot and is sold in rolls of 100 feet or more. For first experiments it is best to try and purchase a shorter piece of negative film from a studio, as they sometimes have pieces left over.

The photograph shows the camera in action. When loading the camera for the first time, it is necessary to see that the film travels freely in its guides and that the claws operate accurately, striking in the holes in the film each time. It may be necessary to bend the claws slightly for this. There should be little or no l st motion in the movement of the claws. After the film has been exposed, it is better to have the development and printing on positive film done by a professional as the apparatus required is not generally found in an amateur's workshop. If the reader desires to do it himself, the method can be found in any of the standard works on moving pictures.

As it is not much use to take the pictures unless one can exhibit them himself, I will go on to describe how the camera itself may be utilized as a projecting machine. Figure (8) shows the idea clearly. The lens box (S) with pillar and base board see Fig. (1), are temporarily removed from the camera and a similar device is built, the camera box being of the same height and width as (S) but one inch longer. The front end is open and the rear is closed with a piece of heavy cardboard with a round hole in it, 1⅜ inches in diameter. To the inner side of this is glued a small condensing lens such as come in certain types of electric torches. A slit is cut in the top and bottom of the box of the same dimensions as in (S) and lined with velvet. The slits must of course be lined up with the film guide below. The upper film reel is removed from its spindle and mounted on a similar spindle in a wooden block set on the top of the camera. The position of the reel is determined by that of a slit cut in the top of the camera, directly over those in the box within, to allow the film to run straight down from the reel. The edges of this slot are rounded and edged with velvet. The illuminant is a 100-watt nitro-filled "Mazda" lamp, called a "stereoptican" lamp and it is set in a wall socket at the rear of the camera. The side of the lamp rests against a circular hole 1½ inches diameter, cut theough the back board of the camera, exactly in line with the center of the box and condensing lens.

The filaments of these lamps are very compact and give a very bright light and the lamp must be so adjusted as to height that the filament is opposite the center of the hole. The shield or lamp house which keeps the light from showing in the room may be made in any convenient way, the easiest perhaps is to take a length of four-inch black stove pipe one foot high, cut a circular opening in one side opposite the hole in the camera and nail it to the block which supports the lamp socket. At the top is set an elbow which throws any light backward, and allows of plenty of ventilation. The projection of the pictures may be done with an ordinary folding camera of which the back can be removed. This is set on a block so that the lens is opposite the center of the front opening of the moving picture camera. A rectiliniar lens will work satisfactorily but of course an astigmat will pass more light and make a brighter picture.

If the cheap grade of lens has been used in the moving picture camera it is better not to attempt too large a picture on the screen on account of the inevitable coarseness of detail. Five feet is about the limit for a pleasing effect. If a fine astigmat lens of very short focus has been used the picture may be much larger. When it is desired to use the camera for taking pictures again the box (S) and support are replaced, as well as the reel and the slots are covered with pieces of cigar box wood, stained black and screwed in place.

Practical Wartime Shell Making*

So many foolish statements have been made in regard to the manufacture of munitions and the possibility of automobile factories, implement works or other equally ill-adapted shops being turned, upon very short notice, into shell factories that it seems well to consider of how little value for the manufacture of munitions is the equipment of the average shop. Outside of the already existing munitions plants, the equipment that manufacturers brought to the business of shell making consisted mostly of their money and credit and the nucleus of an organization. The machinery and tools were more than 90 per cent new, and the greatest success has been made by these companies that were not even owners of machine shops of any kind. All the equipment, enumeration and listing that has been going on may be of some use and the so-called "educational" orders may do some good, but the only thing we are sure of is that very little of tradition, precedent or theory is observed in the conduct of a great war.

The suggestions made here for emergency factory construction are to be understood as applicable strictly to emergency conditions, to meet a demand for an unusual amount of ammunitions with the least possible delay and in no way as suggestions for permanent private or government arsenal construction. In the construction of the plant, the first point to be considered is the locality with reference to labor supply and transportation. Within easy reach of all our large centers of population may be found level, unoccupied, naturally welldrained acreage that is suitable for the purpose and is grid-ironed by railroads; these are the sole requirement for such a plan. Final inspection, cleaning, painting, toolmaking, etc., will be provided for in fully enclosed one-story buildings at the delivery end of the plant; but the large part of the work will be performed with the lightest kind of shelter over machines, operators and transfer track, and circumstances probably will not always justify even this shelter.

The dimensions of the plant should be determined by the size of shell to be manufactured. Units of a given hourly capacity should be located between and perpendicular to two lines of railroad siding at the ends of the plant; one track will be a receiving track and the other a shipping track. The distance between the tracks will represent the proper length of each unit to avoid congestion and afford the simplest movement and transfer of produce. Each unit, commencing at the rear of the plant, will start with an unloading platform and will extend in a double row of opposed machines for the different operations toward the finishing end, where the machinery installation will be replaced by hand operations and inspection, to the packing and shipping track. All machine tools will be horizontally belted, but since space is not considered, the convenience of having all transmission machinery within easy reach is a consideration.

In the construction of the plant, lines of concrete piers will carry the lineshafting; storm-water drains will be placed parallel to these; concrete foundation walls for the machine tools will come next; and transfer tracks will be between the machine foundations. A cutting-compound drain will extend the length of each machine-foundation wall to a sump and pump at the end of the line or at intermediate locations. From each concrete pan under or at the machines, there will extend a chip channel, having a slightly raised bottom, connecting with covered chip tanks sunken in the ground, but readily removable by the cranes. Between each two rows of machines there will be an industrial railway upon which platform cars will be operated; at each machine, car-floor-height platforms will be placed. Such a plant can be erected and operated to capacity within sixty days from the time authority is given to build it.

A complete series of machines for all shell-making operations can be designed along lines that will permit of their construction in immense quantities within thirty days from the time when the necessity for them arises, and at a rate of output that will supply any conceivable demand within the following 60 days. The practicability of such performance has been definitely proved in the last two years; one company accepted orders for hundreds of machines on the guaranteed deliveries of "Commence in 30 days and ship five per cent of any sized order every working day thereafter."

The United States Government can easily be prepared to deliver such machines in the desired daily quantities within 30 days by the following method: In each selected industrial center establish a government plant in which will be stored the necessary patterns, jigs and equipment to make such machines; and in which will also be kept a list of the plants in the territory equipped to make the required parts. Upon order form Washington, the patterns will be shipped to the designated foundries, and, beginning with the third day, castings should be received at the rate of one casting a day per pattern. It will probably require about three weeks to manufacture the various working parts of the machine, but within thirty days at the outside completed machines will be ready to run in the ammunitions plants. The number of machines added to the equipment daily will be the same as the number of patterns from which castings are made. This record can be bettered by stocking in the warehouse the various machine parts, aside from the large bed castings, sufficient to make up machines of a desired daily output during the period found necessary. If this is done, completed machines can be delivered to the munition plants within a week of authorization by the government. The total cost to the government for the patterns, jigs and equipment necessary for such a plan of preparedness will be approximately but $1,000,000.

Retrospection on the days of 1915, when manufacturers were begging for standard machine tools with which to make shells and were given deliveries of eight to eighteen months, shows the necessity for an entirely different provision of emergency machines. To depend at all on current stocks or to hope to utilize to any extent the working equipment of existing shops is equally ill-advised. To cut from new cloth in such an emergency as wartime conditions is the only method that promises success, and there is promise of nothing but disappointment in the attempt to adapt existing shops and machinery.

*Abstract of a paper read before the American Society of Mechanical Engineers, at Cincinnati, May, 1917, by Lucien I. Yeomans of Chicago, Ill.—From *Machinery*.

Change of Conductivity of Minerals By Illumination

Besides selenium, stibnite, and cuprous oxide, certain other substances show an instantaneous response to varying illumination. Over 150 crystalline minerals were examined by exposing them to intermittent illumination from an arc lamp while in circuit with 110 volts and a three-step audion amplifier. The effect was judged by the loudness of the musical note corresponding to the frequency of interruptiion. The new light-sensitive substances thus discovered are: Iodynite—AgI—,silver oxide—Ag_2O—, the simple sulfides of Bi, Mo, Ag. and Pb, and certain compounds of either Pb or Ag with sulphur and either Sb or As, known as pearceite, miargyrite, jamesonite, boulangerite, bournonite, pyrargyrite, proustite, stephannite, and polybasite. Bismuthinite —Bi_2S_3—is classed as "very good," though its resistance is over a megohm in a mm.-cube.—Note in *Science Abstracts* on a paper by T. W. Case in *Phys. Rev.*

Under-Sea Instinct of the Sea Lion

We cannot remember a winter for many years when persistent cold over such lengthy periods froze our ponds and pools to such a depth as in 1916. On larger bodies of water it was impossible to keep open a greater area than mere airholes. This has been the condition of the big sea-lion pool and incidentally has worried many visitors who have thought the animals would drown. To those unitiated into the ways of these creatures, it is disconcerting to see the big Stellar sea-lion plunge into an opening of the ice about four feet in diameter, note the agitation of the small area of water absolutely cease, then look over the large surface of soldily-frozen pool. Visitors reason that the animal can never find its way back to the opening, but after several minutes of painful suspense, the object of apprehension pokes out his head, barks vigorously for his associates to join him, then dives again.—*New York Zoological Society Bulletin.*

Color and Color Photography*

A Review of Problems Involved, and Methods of Working

By C. D. Hodgman[1]

BEFORE taking up the discussion of color photography it is of advantage to consider some of the facts concerning color. The particular points which are of interest in this connection are:

1. Color sensation and specification.
2. The Young-Helmholtz theory of color vision.
3. Sources of color.
4. Methods of color synthesis or color mixing.

We consider light to be a wave motion of the ether which stimulates the optic nerve by way of the retina of the eye, producing a sensation which we designate by the same name—light. The normal eye not only distinguishes light and darkness but may differentiate between one light and another equally bright which, as we commonly express it, is of a different color. The physical characteristic which gives rise to this distinction is a difference in the frequency of the ether disturbances which reach the eye.

Our experience in the study of sound shows that the nature of the sensation produced by a simple tone depends on the frequency and intensity of the vibrations producing it. In an exactly analagous manner the sensation produced when light enters the eye depends on the frequency or wave length and on the intensity of the incident waves. In the above statement it is understood that the wave length is the distance between the crests of two successive disturbances as they exist in the medium and that the frequency is the number of disturbances sent out in one second. These two quantities are reciprocals of each other when the velocity of propagation is constant as is the case for a homogeneous medium for both sound and light. Hence, under these conditions, any function which varies as the frequency will vary inversely as the wave length.

Just as the sensation produced by a complex musical tone depends on the frequencies and intensities of its various components, the sensation produced by light depends on the wave lengths and intensities of the separate vibrations which combine to give the sensation The eye, however, possesses less power of analysis than the ear. Tones which differ in their composition produce different sensations; very small differences in frequency can be detected, and the audible limits extend from about fifteen to above ten thousand vibrations per second. The limits of the visible wave lengths correspond to only about one octave in musical tones—3,900 to 7,600 Angström units. The limited power of differentiation possessed by the eye is also shown by the fact that it is possible, by allowing light of three single selected wave lengths to enter the eye simultaneously, to produce a sensation indistinguishable from so-called white light; although white normally consists of a combination of all wave lenghts within the limits of those having any visual effect.

Color terminology is not entirely satisfactory—the term white light, for instance, is only relative. For ordinary purposes we may consider daylight as white light. As a standard we may accept the color of a so-called black body heated to 5,000 degrees absolute as white; this color will appear reddish, however, if compared with daylight. For the description or specification of a color, three properties are considered, namely: hue, luminosity and purity. The first property, hue, is known if the wave length of the predominant light is known and may be directly or indirectly specified by a wave length. The second, luminosity, is merely visual brightness. The third, purity, is used to signify the relative extent to which light of any given hue is mixed with white. The distinction between the first and the last term may be made clear if we consider light of a single wave length, having therefore a definite hue, to be altered by the addition of white light. The hue remains the same, that is the dominant wave length is still the original, but the color which was at first pure is so no longer.

The explanation offered for the phenomena of color vision by the Young-Helmholtz theory involves the fundamental supposition that there are three primary color sensations. Three sets of nerve ends have been suggested giving when excited the sensations red, green and blue-violet respectively. The exact physiological explanation of the three sensations is unimportant, the essential feature being the three distinct sensations giving all other colors when excited together in the proper proportions. It has been indicated that each sensation is excited principally by a definite group of wave lengths, the sensation of red being experienced upon excitation of the retina by the longer visible wave lengths, while the medium and shorter wave lengths produce green and blue sensations respectively. Curves showing the relative sensitiveness of each sensation-producing mechanism to different wave lengths can be determined. It is to be noted that the region of excitation for a given sensation is not sharply defined. The sensation of red, for instance, while principally excited by the longer wave lengths shows a measurable response to all wave lenghts which produce any visual effect whatever.

The occasional abnormal condition of the human eye, known as color-blindness, is well accounted for by this theory; the explanation being that one or two of the sensations are partially or wholly missing. Another notable phenomena which seems to support this theory is retinal fatigue. If the retina is strongly excited for some time by light of a given hue, which mainly produces one or two only of the three possible sensations and is then immediately excited by white light it appears as if the mechnism of the sensation or sensations produced had been fatigued since the dominant hue perceived is now that caused by the sensations not prevoiusly excited. This may be illustrated in a simple manner by preparing two sheets of paper—one of a bright, saturated color, say magenta; and another, larger, of white. Place a black dot at the center of each sheet and with the two sheets strongly illuminated gaze fixedly at the dot in the center of the magenta sheet for about thirty seconds. The gaze is then to be suddenly transferred to the dot in the center of the white sheet. There would now appear an area of pale green on the white paper similar in size and shape to the magenta sheet. Magenta is produced by the simultaneous sensations of red and blue-violet; the mechanism producing these having been fatigued, the incidence of white light on the retina gives principally the unfatigued or green sensation.

Probably the most important fact which forms the basis for the three-color theory and one which is the working hypothesis of all present practical methods of color photography is that all known colors can be reproduced by combining, in varying proportions, light of three selected wave lengths which, if viewed separately, would give the sensations red, green and blue-violet.

The facts cited above, together with various others, seem to show that the Young-Helmholtz theory offers the most practical and conveninet explanation of the phenomena of color in connection with its reproduction by photographic processes.

The principal sources of color are of three types: First, color due to the wave length of the original radiation; second, colors by dispersion or interference; and, third, colors by selective absorption or selective reflection. The radiations from various sources vary from a few single wave lengths to all possible values between the visual limits with a corresponding range of color. We recognize the differences in the colors of light sources not only in flames charged with the vapor of metallic salts as used in pyrotechnics but also in the various types of artificial illumination.

Dispersion and interference form the basis of methods used to separate the radiations from a light source in such a manner that separate images of the source are formed for each wave length present. Each image will then appear of a color characteristic of the wave length which produced it. The series of images thus formed constitute a spectrum, the colors thus produced being called spectrum colors. These are the familiar "rainbow colors" usually indicated as red, orange, yellow, green, blue, indigo and violet, with the intermediate hues. Certain modifications of these appear when the images are allowed to overlap more or less, but in any one spectrum the colors observed are limited to those named above. Colors produced by the combined effects of groups of wave lengths not contiguous in the spectrum would not appear, the most notable case being the series of colors variously designated as purple, pink or magenta.

Many substances absorb or reflect light independently of its wave length. Such substances will always appear to be the color of the light with which they are illuminated. Many other substances, however, possess a property called selective absorption or reflection by virtue of which they transmit or reflect certain wave lengths, but absorb others. The color of the substance is then the color of the light it transmits or reflects; depending not only upon the characteristics of the substances, but as well upon the light which illuminates it. The varied appearance of colored objects when viewed by daylight and by the various artificial sources of light is a good example. The larger part of the colors in nature are produced by selective reflection or absorption; the the natural coloring matters of the animal and vegetable kingdoms, artificial dyes, stains and pigments are all instances of this phenomenon. Colors in nature produced in other ways are less common; the rainbow, halos around the sun or moon, the iridescence of certain insects and of sea shells are some of the more common examples.

As has been suggested, all known colors may be produced by optically adding various proportions of red, green and blue-violet light. There are several methods of accomplishing this addition and we may vary the three primary colors from narrow spectrum lines to portions of the spectrum which combined would include the whole range of visible radiations and without sacrificing to any extent the accuracy of the color reproduction. The most direct method of addition is triple projection in which the three selected colors are projected superposed on a white screen by means of an appropriate system of lenses. Suitable adjustable diaphragms in the projection lenses allow the full range of variations in the relative intensities of the three components. The color wheel, a disk showing variable sectors of the three colors and, when rotated rapidly enough, their combined effect, is another well-known method of synthesis. A third method is the use of very small elements of red, green and blue-violet, each element in itself being too small to be distinguished by the naked eye. The effect when viewed is the sum of the effects of the elements and depends on the relative numbers of each color distributed over the area in question. Addition is also accomplished by transparent mirrors of plate glass, a system having been devised whereby light from three color screens is brought simultaneously into the line of sight.

Quite distinct from these methods of synthesis by addition, synthesis by subtraction still accomplishes the same results. In this we start with white light and subtract from it various proportions of the three primary colors, red, green and blue-violet. This may be done by transparent films which selectively absorb the groups of wave lengths which give the sensations. A screen absorbing only the wave lengths corresponding to the red sensation would appear bluish-green, one absorbing green would be magenta or pink and one absorbing blue would be yellow. The superposition of the three absorbing filma gives practically the full range of known colors by proper adjustment of the relative strengths of the absorbing media. With the exception of the color wheel all the above mentioned methods of color synthesis are used in the various processes of color photography.

Three-color photography consists first of an analysis of the colors of objects by means of negatives made on specially selected color sensitive plates and using proper color screens, and second, the synthesis of the color elements to reproduce the original effects.

The main problems involved are:

1. The determination of proper plates of requisite color sensitiveness.
2. The fitting of filters to limit the action on the plates to the proper wave lengths.
3. The choice of reproduction colors.

Upon the accuracy of the solution of these problems depends the possibility of producing successful color photographs. The actual processes also involve a considerable amount of technical detail which is often a serious difficulty in the way of accomplishing the desired results.

The ordinary photographic dry plate, consisting of a sheet of glass coated with an emulsion of silver bromide in gelatine, is sensitive principally to the shorter wave lengths, violet and blue. The yellow and red parts of the spectrum show effects only by temendously prolonged exposure. Such plates cannot be successfully employed to reproduce images of the green and red sensations. Fortunately the addition of minute quantities of certain organic coloring matters to the emulsion increases the sensitiveness in various parts of the spectrum and among the large number of plates now on the market thus color sensitized one may choose such as are suitable. An alternative method is to bathe the ordinary blue-sensitive plate in weak solutions of the proper dyes, the results being as good as with commercially sensitized plates. The process, however, forms a worthy

*A paper presented before the Cleveland Engineering Society, and published in its *Journal*.

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research problem in itself. In whatever way the plates are procured final judgment as to their suitability must be made from photographs of the daylight spectrum taken upon them. The same method is necessary in testing filters for use with the plates.

Filters may be used in front of, behind or between the components of the lens or close in front of the plate. Dry sheets of stained gelatine may be used in front of the plate supported on thin glass or on the plate itself. When used near the lens the outer surfaces of the filter must be plane parallel or very nearly so in order to avoid distortion of the image. The coloring matter may be in solution in cells or in sheets of gelatine. The important element in the making and fitting of filters is the choice of stains and may well be the subject of extended experiments. A dry filter of small size to be used in front of the lens offers the greatest advantages for experimental work. It may consist of two pieces of thin selected mirror plate each of which bears a coating of properly stained gelatine, the two coated surfaces being cemented together with balsam. The questions to be answered are—what wave lengths should be included for each sensation, whether or not the action should overlap and to what extent. In general, narrow filters, that is, filters passing only narrow portions of the representative red, green and blue-violet parts of the spectrum, appear to give more brilliant results but perhaps a less accurate reproduction of color. The wider filters produce softer photographs and seem to give a more strictly natural rendering. The theoretically correct combination of plate and filter would be that which would give for any part of the spectrum an opacity of silver deposit on the three negatives proportional to the stimulus given to the three color perceiving elements of the eye by the same wave length.

The exposure of the three plates may be made successively in a single camera or all at once in a camera especially constructed to give three images from a single lens. Even in the latter case an exposure several times the normal is required. The three negatives thus obtained form a record of the magnitudes of the red, green and blue-violet sensations to be obtained from the various parts of the object photographed; in other words, a color analysis has been made.

There are various means of performing the synthesis so as to obtain positives in color. The method of triple projection uses black and white positives, made in exactly the same manner as are lantern slides, one from each of the three negatives. They are projected simultaneously through red, green and blue-violet light filters in such a way that the images are exactly superposed. Although excellent results have been obtained the scheme requires a special projection lantern and positives of this sort can be used otherwise only in an arrangement of transparent mirrors which is not wholly satisfactory.

Another method is to make three positives in gelatine on celluloid or other transparent support, by the bichromate process. This is similar to the familiar carbon process of making monochrome prints except that the carbon or other pigment in the gelatine is replaced by silver bromide. This serves as a guide in printing but may be dissolved by a solution of sodium thiosulphate ("hypo") leaving a picture in clear gelatin which may be stained by immersion in a dye solution. The three positives are each colored with a dye which will absorb the light which produces the sensation which it represents. The positive from the red sensation negative is stained greenish blue; that from the green sensation negative, pink, and that from the blue sensation negative, yellow. These three positives, when superimposed, form a transparency in the natural colors of the object. A modification of this method affords very good positives in color on a paper support. When made as transparencies they may be projected by any ordinary lantern requiring to be rather well illuminated by a white light. Several successful methods involving these principles have been worked out and put upon the market under various trade names.

Another type of process, different in many ways but still based on three-color analysis, is called the screen plate process. One plate is used in place of three. The sensitive film of silver bromide, properly balanced as to color sensitiveness, is exposed directly behind and in contact with a screen the full size of the plate and consisting of very small elements of red, green and blue-violet. These divisions may be lines, squares, hexagons or of irregular shape, but must be small enough to be invisible individually and the proportions of the three colors to each other such as to give a neutral light gray effect when viewed directly. When well illuminated and observed in contrast with other colors it will appear white.

The Autochrome is one of the well-known screen plates and will serve as a good example of its kind. A glass plate is coated with an adhesive and starch grains which have been dyed separately red, green and blue-violet and mixed so as to appear a neutral gray, are spread upon this plate in a single layer. The spaces between the grains are filled with an opaque substance. The starch grains are protected by an impermeable varnish and a very thin color sensitive emulsion laid upon it. The plate may be exposed in an ordinary camera, the uncoated surface toward the lens, the screen of colored starch grains coming between the lens and the sensitive emulsion. By a simple chemical process a positive is produced directly. We have here a transparency of three parts, a positive in red starch grains, one in green and one in blue. These three coexist on the same plate. their effects are added and the original colors reproduced. The finished positive may be used as a lantern slide with sufficient illumination.

Other screen plate processes differ in details. In some cases the color screen is separate, a plate carrying the sensitive emulsion being exposed behind and in contact with it. This plate is then developed as a negative and positives made from it are bound up with a screen similar to the original and upon proper adjusting the colors are reproduced.

Interesting and valuable modifications of existing methods are constantly coming to notice and the art of color photography, which was, not so very long ago, confined to the laboratory of the scientific expert, is now sufficiently simplified to be undertaken by the amateur and by reason of the improvement in results as well as convenience is taking a more important place in science and art.

Altitude of Bird Flight

"An officer of the French Flying Corps, who may be identified with a valued fellow-worker of the R. S. P. B., has taken exceptional opportunities to record observations on the flight of birds and the height at which they fly, especially when migrating. Some of his notes are published in the *Pall Mall Gazette* (Vol. 11, 1916). Swallows, he says, seem to prefer an altitude of 2,000 feet, whereas the wild duck usually fly at 5,000 feet. They are remarkable, also, for the marvelous uniformity with which they follow their leader. The turns and twists are taken with such simultaneity that a flock appears to turn and wheel automatically, so extraordinarily together do they move. When climbing they fly at about sixty-five miles an hour, and are good for 70 once they have got their height and have spread out to let themselves go.

"Last march, he met some plovers at 6,500 feet, which is the highest altitude that he has seen a company of birds."—From *Bird Notes and News.*

Action of Lead as a Stimulant for Plants

The results of water culture experiments with rye, wheat, oats, barley, maize, and peas showed better growth when a portion of the nitrogen was in the form of lead nitrate than with sodium nitrate only. The best plants, especially barley, were obtained in solutions containing 0.5 grams of lead nitrate per liter. In field experiments the yields of sugar beet and of sugar were considerably increased by application of 4 kilos of lead nitrate per hectare. With oats the yield of grain was increased, while the yield of straw was diminished. The same amount of lead nitrate (4 kilos per hectare) gave unsatisfactory results with potatoes, which seem to be very sensitive to lead nitrate. Another field experiment, with wheat, showed that while lead nitrate gave good results in conjunction with 60 kilos of nitrogen as sodium nitrate, the results were much less satisfactory when smaller amounts of sodium nitrate were employed. —A. Stutzer, in J. Landw. From a note in the *Journal of the Society of Chemical Industry.*

Stepped Ignition of Gases

The researches of Thornton (*Jour. Soc. Chem. Ind.*) 1916, 682) appear to show that the curve connecting the minimum igniting current with the pressure in a given mixture of combustible gas and air, consists of a series of vertical and horizontal portions which he terms steps. The present author has carefully determined for a mixture of methane and air (9.5 per cent CH_4) at varying pressures the minimum current passing through the primary circuit which just causes ignition when the spark gap and the rate of break in the primary circuit are both kept constant. His results lead to a perfectly smooth hyperbolic curve, suggesting that Thornton's results are due to some peculiar conditions of experiment. Mathematical analysis of the curve (by A. Greenwall) suggests that the quantities "observed igniting current" and "observed degree of compression" are mutually involved and that for the true interpretation of the curve the axes of coördinates should be inclined parallel to the asymptotes of the hyperbola.—Note in *Jour. Soc. Chem. Ind.* on a paper by R. V. Wheeler in *Chem. Soc. Trans.*

Shells and Hand Grenades of Cast Iron

At a meeting of the American Foundrymen's Association Edgar A. Custer of Philadelphia, now a major in the ordnance division of the United States Army pointed out the superiority of cast iron shells against earthworks. He also stated that the efficiency of a shell fired against troops is dependent almost entirely upon the character of its fragmentation, in which particular cast-iron shells have been shown to be much more satisfactory than forged-steel projectiles. Cast-iron shells, with proper foundry procedure, can be easily made in enormous quantities, he claimed. France, he said, is making over 1,000,000 rounds a day at present in dry-sand molds. The cost of steel forging for a 4.7-inch shell he put at over $7, and a cast-iron shell of similar size at a little over $2.

At the same meeting material for hand grenades was discussed, and some experiments in a bomb-proof were referred to. When grenades of cast iron were exploded nothing resulted in the way of destruction, and there was scarcely anything save a powder of cast iron. With malleable iron large fragments resulted, and some of them went through the 1-inch pine box like bullets.

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, DECEMBER 22, 1917

Published weekly by Munn & Company, Incorporated Charles Allen Munn, President; Frederick Converse Beach Secretary; Orson D. Munn, Treasurer, all at 233 Broadway, New York

Entered at Post Office of New York, N. Y., as Second Class Matter

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The Scientific American Publications

Scientific American Supplement (established 1876) per year $5.00
Scientific American (established 1845) 4.00
The combined subscription rates and rates to foreign countries, including Canada, will be furnished upon application.
Remit by postal or express money order, bank draft or check.

Munn & Co., Inc., 233 Broadway, New York

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